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# A REPORT ON LOCATION AND DESIGN

# GARRISON EAST & WEST

# INTERSTATE ROUTE 90

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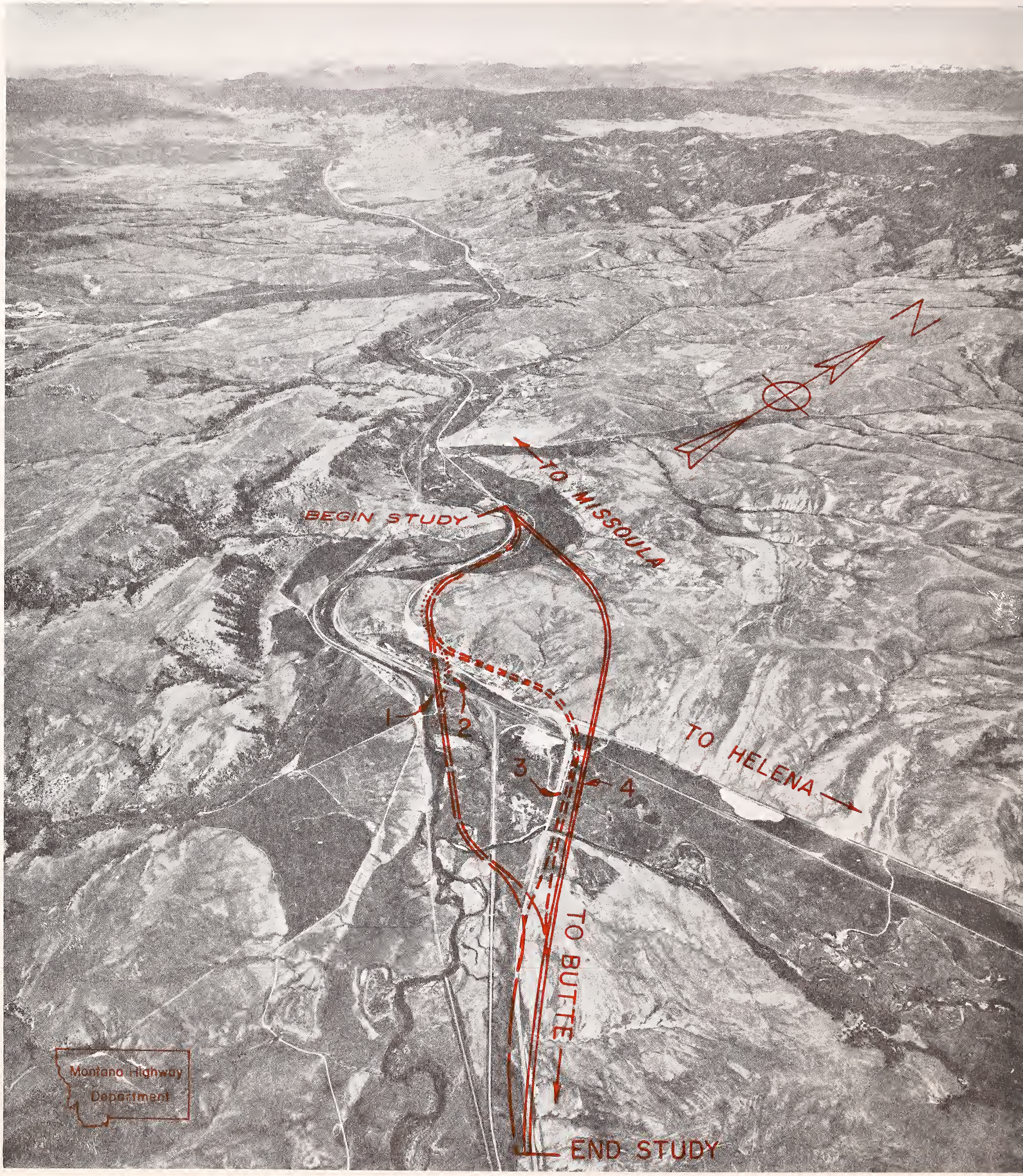

THE GARRISON LOCATION STUDY AREA LOOKING WEST TOWARD MISSOULA

# A REPORT ON
# LOCATION AND DESIGN

# GARRISON EAST & WEST
# INTERSTATE ROUTE 90

## STATE OF MONTANA

MARCH 1968

PREPARED FOR

MONTANA HIGHWAY COMMISSION

PREPARED BY

MORRISON-MAIERLE, INC.

HELENA, MONTANA

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# A REPORT ON LOCATION AND DESIGN

## Foreword

The authorization for this report is an agreement between the State of Montana, acting through its Highway Commission and Morrison-Maierle, Inc., Consulting Engineers. Interstate Route 90 enters Southeastern Montana at Wyola, goes through the cities of Billings, Butte and Missoula and terminates at the State's western boundary at Lookout Pass. The area of study lies approximately one-third the distance from Butte to Missoula in Powell County near the Town of Garrison.

The purpose of this report is to present evaluations on alternate locations for the 4-lane Interstate Highway from the project beginning two miles west of the Town of Garrison to the project terminus two miles south of Garrison. The four mile project covered by this report is within the section designated by classification of the Montana Highway Department as Engineering Project I 90-3(7) 168.

The information herein presented is the result of extensive engineering studies conducted by the Consultant of all feasible highway locations within the corridors specified in the formal agreement. The study includes information on the following items as they are related to all alternate locations considered:

1. Geometrics
2. Soils & Geology
3. Hydraulics
4. Interchanges
5. Access Solutions
6. Design Standards
7. Construction Cost Estimates
8. Economic Analysis

All alternates will have to cross the Little Blackfoot River and the Northern Pacific Railway. Costs of the structures necessary to cross these features greatly influence the geometrics of the alignment locations.

Preliminary evaluation of prospective locations on the site and on topographic maps resulted in the decision to study in detail the alignments shown on the Location Plan and described in the following text. The same extent of detailed consideration regarding grades, cross-sections, curves, drainage, structures, etc., was accorded all alternates.

Alternate line study was made from photogrammetric reconnaissance maps furnished by the Montana Highway Department. The contours on the maps were at 2 foot intervals except where steep slopes required intervals of 10 feet. The scale of the maps were at one inch equals 100 feet. Ground line profiles and cross-sections were plotted from these maps. Cross-sections were plotted at intervals of 200 feet and at major topographic breaks. Grades were laid and earthwork quantities were computed from the cross-sections.

## GEOMETRICS AND LOCATIONS

### General

The westerly terminus of the study area is the east end of the 4-lane Gold Creek Interstate project currently in design by this Consultant. The easterly limit is the center of this 4-lane Garrison E-W Interstate project and is the beginning of the preliminary alignment shown as Station 200+00 at the Preliminary Plan-In-Hand. The lateral study limits are the Clark Fork and Alternate 4 as described in this report. At the westerly terminus the centerline to centerline distance of the pairs of lanes is 180 feet. At the easterly end the lanes are on individual alignments both horizontally and vertically.

The area of study traverses a mountainous ridge immediately north of the town of Garrison. The majority of the earthwork cost on all alternates is incurred in crossing this ridge. Two paths are used in this crossing. The first is in the vicinity of the present highway. The second is several thousand feet easterly at a saddle in the ridge. A crossing of the ridge up the drainage behind Garrison was inspected but was found too steep on the westerly side for feasible construction.

All alternate locations are planned to cover the existing highway from a few thousand feet southeasterly of the Little Blackfoot River Bridge on to the southeast. That portion from Garrison to the land southeast of the river will remain for access purposes.

On page 4 is a summary of the geometric features of the studied alternates.

### Alternate No. 1

From the westerly terminus of the study Alternate 1 is parallel with the present highway to the pass in the previously mentioned ridge. At this point it bears directly southward generally parallel with the Clark Fork. Directly south of the Little Blackfoot River crossing the alignment splits and each pair of lanes continues on an independent horizontal and vertical alignment to the end of the study. The maximum horizontal distance between centerlines in this area is 430 feet.

The structure over the railroad tracks in Garrison is planned sufficiently long to provide access along the tracks on both sides. Due to this only one multiple track crossing will be required. This crossing is planned near where the existing crossing is now. Access to the old steel river bridge as well as access to each side of the town of Garrison would remain. Alternate 1 has the highest initial cost which is largely attributed to this structure over the railroad.

## Alternate No. 2

Alternate 2 is identical with Alternate 1 except that the bridge over the railroad tracks is turned to reduce the amount of skew angle. This adds three additional curves where Alternate 1 is tangent. This structure, as on Alternate No. 1, is long enough to accommodate access on each side of the railroad tracks.

## Alternate No. 3

This alternate is very similar to the alignment previously established by the Highway Department in their "Engineering Report Comparing Alternate Locations Interstate Route 90 Garrison E & W". In that report it was entitled "Town Line". Alternate 3 differs from the "Town Line" in that it does not cover the existing highway either through the ridge west of Garrison or North of the highway bridge over the Little Blackfoot River. Also, an independent alignment is employed south of the Little Blackfoot River.

This alternate would take the Garrison school house. It is the longest of all alternates and it has the highest annual cost.

## Recommended Alternate No. 4

Alternate 4 was entitled "Hill Line" in the previously mentioned Highway engineering report. The major difference between Alternate 4 and the "Hill Line" is south of the Little Blackfoot River where Alternate 4 is on independent vertical alignment at approximately 120 feet centerline to centerline. The distance between centerlines over the hill is 70 feet.

This alternate is the shortest alignment studied. It incurs the most earthwork excavation but has the least annual cost.

## Explanation of Geometric Summary

In proper evaluation of highway locations, comparisons of geometric features must be made. To simplify comparisons the following table lists the studied alternates and the corresponding geometric data. Derivation of the data is as follows:

$$\text{Length} = \frac{\text{Eastbound Length} + \text{Westbound Length}}{2}$$

$$\text{Average Grade} = \frac{\text{Total Elevation Rise and Fall}}{\text{Total Alternate Length}}$$

$$\text{Maximum Grade} = \text{Maximum Grade}$$

$$\text{Percent of Curvature} = \frac{\text{Total Length of Curves} + \frac{1}{2}\,\text{Total Length of Spiral}}{\text{Total Alternate Length}}$$

$$\text{Average Degree of Curve} = \frac{\Sigma(\text{Degree of Curve} \times \text{Length of curve} + \tfrac{1}{2}\ \text{Degree of Curve} \times \text{Length of Spiral})}{\text{Total Length of Curve} + \tfrac{1}{2}\ \text{Total Length of Spiral.}}$$

$$\text{Maximum Degree of Curve} = \text{Maximum Degree of Curve}$$

$$\text{Total Horizontal Deflection} = \Sigma(\text{Curve } \Delta\text{'s})$$

| GEOMETRIC FEATURES | | | | |
|---|---|---|---|---|
| ITEM | ALTERNATE | | | |
| | 1 | 2 | 3 | 4 |
| Length | 3.92 Mi | 3.97 Mi | 4.18 Mi | 3.77 Mi |
| Average Grade | 1.70% | 1.73% | 1.88% | 3.17% |
| Maximum Grade | 3.80% | 4.00% | 4.00% | 5.00% |
| Percent of Curvature | 45% | 56% | 64% | 78% |
| Average Degree of Curvature | 2.45° | 2.43° | 2.25° | 0.58° |
| Maximum Degree of Curvature | 3.5° | 3.5° | 3.5° | 1.25° |
| Total Horizontal Deflection | 237° | 304° | 325° | 94° |

## GEOLOGY

### Geologic History

The sediments involved in the project area were deposited during middle-late Cretaceous time about 65 million years ago. The Carter Creek formation includes approximately 4,500 feet of marine, brackish and partly fresh water deposits. This formation is the product of the final regression of the Continental Cretaceous Sea from the Clark Fork Valley. Detailed sequence of events during this regression is speculative due to the poor exposures of this formation, however, near shore deposits of marine origin interfingered with varicolored beds of probable continental origin suggest oscillatory migrations of the sea over considerable geologic time just prior to the Laramide uplift.

The Golden Spike Formation lies above the Carter Creek Formation in the depositional mode and is composed of 5,000 to 8,000 feet of volcanic and nonvolcanic rocks. It is difficult to establish where the Golden Spike Formation begins and the Carter Creek Formation ends in this area due to the similarity in lithology of the lower nonvolcanic Golden Spike Formation and the upper nonvolcanic Carter Creek Formation. A pebble-cobble conglomerate forms the base of the Golden Spike Formation in the type-section to the west, however, it is not exposed in the project area. Laramide folding and erosion in the project area appears to have triggered massive slides and flows in the area which is in evidence in the railroad cuts west of Garrison where large blocks of volcanic and nonvolcanic rocks are hinged with a conglomerate matrix and show a marked change in dip and strike.

The non volcanic rocks were deposited on an alluvial plain adjacent to the highlands. Volcanic sediments which appear to pinch out to the west were probably transported from the east and southeast. The exposed clastic chert pebble debris near Garrison were transported from the west. The result of this interfingering phenomena is a bedding complex in which the sediments are alternately volcanic and nonvolcanic. Subsequent folding, structural movement, and spasmodic erosion with transportation, and mass flows with landslides, have left this area in its present form. The Clark Fork River has shaped the valley floor topography and is continuing the erosional process. Flat lying tertiary sediments and Quarternary gravels overlie the folded Golden Spike and Carter Creek strata along the low benches throughout the area.

### Effects of Geology on Engineering Design

A limited exploration program was authorized to examine Alternate 4 where there would be high fills and the deepest cut of any alternate location. Three holes were bored. Two were in areas requiring highway embankment heights of 60 and 35 feet at stations 32+00 and 101+00 and were drilled 28 and 22 feet deep respectively. The cut hole was at the point of maximum roadway cut depth and was 100 feet deep. The roadway design on Alternate 4 was based primarily on the laboratory test results of the materials found in these holes. However, surface inspection was also employed.

Results from the cut hole showed layers of materials of poor stability. The backslope of 2:1 with benches used for earthwork quantities for this report was based on the findings of this test hole. However, slopes at which these less stable materials lie cannot be determined from one test hole and there is a possibility that the backslope angle would have to be flatter or steeper.

The design of the other three alternates was based solely on surface inspection. Examination of the present roadway and railroad cuts were of great value.

Perhaps the most important factor influencing the slope design is the presence of a gray chert pebble conglomerate which occurs in 6 inch to 5 foot thick lenses in both the lower Golden Spike formation and the Upper Carter Creek Formation. This material breaks down rapidly into a gray clay and has varying qualities of compaction. The designs are based on an estimate of 30% to 40% of this material being in the major cuts and that this material will be used for fill in the adjacent embankments and abutments. Selective mixing of coarser grained material or wasting methods will affect the foundation design in this material.

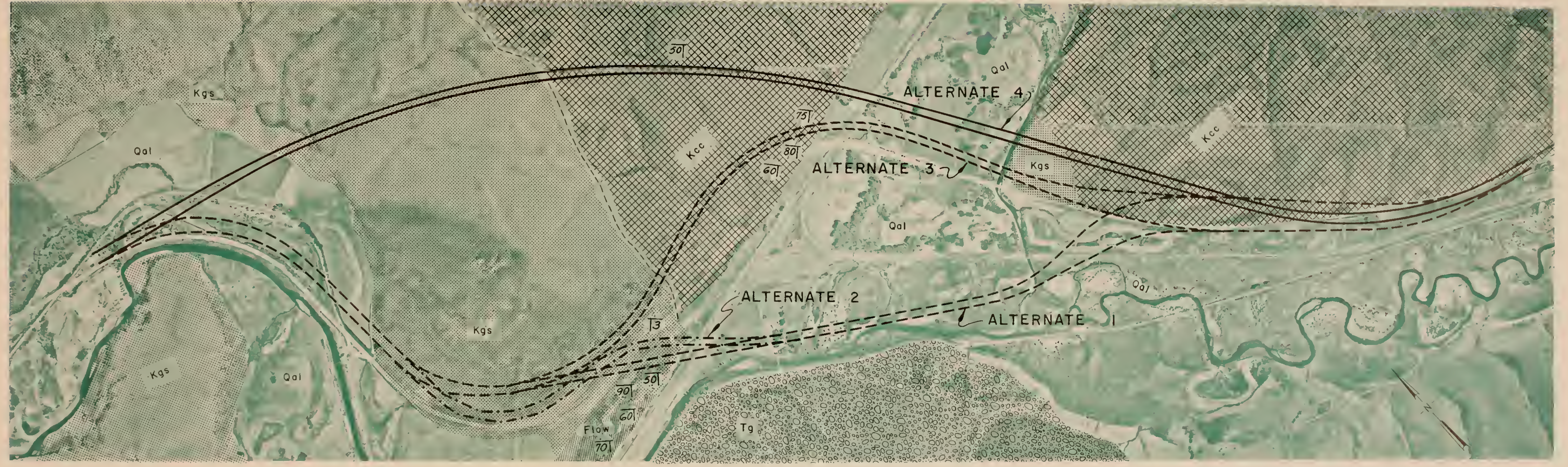
Blocks of sand stone, mudstone and siltstone outcrop in an alternating pattern and appear to be unstable where dipping into the roadway. However, the existing cuts for the railroad and highway are standing at ½:1 to 1:1 without apparent slide or slumping problems. The material where exposed weathers to claysoil rather rapidly in the volcanic rich beds which appear sporadically throughout the section.

Except for the areatraversed by Alternate 3 from Station 74+00 to 100+00 and Alternate 4 from Station 40+00 to 100+00, all cut backslopes are expected to stand at 1½:1 within the other limits backslopes should be 2:1. All backslopes north of the Helena - Missoula existing highway will require benches where the vertical height of backslope exceeds 40 feet.

All fill slopes on Alternates 1, 2 and 3 from Station 0+00 to 100+00 should be 3:1 where an embankment height of 20 feet is exceeded. All other fill slopes should stand at 2:1.

Subsurface excavation is expected to be necessary between the Helena-Missoula existing highway and the N.P. Railway to remove organic materials of poor supporting stability. Bridge abutment fills will have to be constructed

# GEOLOGY EXHIBIT



## EXPLANATION

| | |
|---|---|
| Qal | QUARTERNARY ALLUVIUM – SLOPE WASH, TALUS, STREAM SAND AND GRAVEL, REMNANTS OF GRAVEL BENCHES |
| Tg | TERTIARY – PEDIMENT CAPPED MIOCENE VALLEY FILL |
| Flow | VOLCANICS – PYROCLASTIC FLOWS, SOME DARK CONGLOMERATE, MAINLY ANDESITIC |
| Kgs | GOLDEN SPIKE FORMATION -- GRAY VOLCANIC RICH PEBBLE-COBBLE CONGLOMERATE |
| Kcc | CARTER CREEK FORMATION – GRAY-GREEN AND TAN SANDSTONE, SILTSTONE, SHALE, AND MUDSTONE, WITH SOME LENTICULAR CONGLOMERATES |
| 3 | DIP & STRIKE IN DEGREES |

of selected or quarried material to provide stable 2:1 slopes. A shrink or swell factor of 1.0 has been used for all earthwork calculations. Ground water problems are not anticipated.

From a geological point of view the best alternate is Alternate 2, primarily because the large cut is parallel to the dip slope and the existing cuts appear to stand well. Alternate 4 is the least favorable line due to the absence of outcrop data, the generally suspicious nature of the erosional pattern and coulee formation as well as the incomplete test hole data.

# DESIGN STANDARDS AND CRITERIA

## General

Design criteria are based on those acceptable for the Interstate System. This is outlined in the pamphlet entitled "Geometric Design Standards for the National System of Interstate and Defense Highways" adopted by the American Association of State Highway Officials (A.A.S.H.O.) and the U.S. Department of Commerce, Bureau of Public Roads. This is the criteria used on Interstate Highways throughout the Nation which involve the use of Federal Aid funds. Incorporated as design guides are the book publications of A.A.S.H.O., "Policy on Geometric Design of Rural Highways," and "Standard Specifications for Highway Bridges." The "Field and Office Standards" and "Standard Drawings" publications along with other current written standard practices of the Montana Highway Department are also used as guidelines.

The design speed in this area has been maintained through this study as 70 M.P.H. Review of the projects on each side of this area shows that very high type design is possible and is planned. In a distance of at least 10 miles on either side of the study area there is to be only one 3 degree curve. This will be in the Gold Creek East project. Continuity of design will provide immeasurable value in hazard reduction.

All design criteria for 70 M.P.H. were used throughout. Minimums were considered undesirable and were not used except where dictated by excessive cost considerations. The minimums referred to here are $3^{\circ}$ 30' curves and 5% grades.

# INTERCHANGES

## General

An extensive study was given the various possible interchange patterns on each alternate location.

Plan layouts at a scale of 1 inch equals 100 feet were developed on contour maps. Profiles were made from these at 1 inch equals 100 feet horizontally and 1 inch equals 10 feet vertically for all crossroads, ramps and access roads.

The following text and diagrams discuss only the most feasible of the layouts studied. Some patterns were applicable to more than one alternate. All interchange designs were in conformance with current Montana State Highway Criteria.

The interchanges that accrue the least annual cost on each alternate are the ones that are shown in the plans and included in the cost summary. These interchanges are:

Alternate 1 - Pattern 6
Alternate 2 - Pattern 12
Alternate 3 - Pattern 7
Alternate 4 - Pattern 13

## Alternate 1

The most feasible location for an interchange on this alternate is near Station 60+00. The U.S. 12 connection to the Missoula side of the interchange has the majority of the interchange traffic. The more directly that Helena and Missoula can be linked, the less road user cost will be incurred. Due to the imbalance of traffic, the further south that the interchange is located, the greater the user's cost will be. An interchange south of Station 90+00 would be south of the long Interstate railroad overpass bridge and would necessitate an additional structure over the railroad to connect U.S. 12 to this interchange.

Both interchange plans of local road over the Interstate and local road under were evaluated at Station 60+00. The local-over develops the least cost and is the arrangement that is included in the cost summaries. Two possibilities exist for access from this proposed interchange area to Garrison. The first is by way of an access road sidehilling the mountain on the easterly side of the Interstate. The second is by way of the present traveled way bridged under the Interstate. These two layouts are designated Pattern 6 and Pattern 8 respectively and are shown in diagramatic form on page 13 . The cost summaries include Pattern 6 on Alternate 1.

## Alternate 2

A situation similar to Alternate 1 exists on Alternate 2 and similar interchange layouts provide the same traffic service. However, because the Interstate centerline lies more to the west in the interchange area, ramp and cross road locations are slightly different. Pattern 8 on Alternate 2 differs only in Interstate location from Pattern 8 Alternate 1. Pattern 12 on Alternate 2 is similar to Pattern 6 on Alternate 1. These patterns are shown diagramatically on page 15 . Pattern 12 is the interchange included in the cost summaries with Alternate 2.

## Alternate 3

This alternate could have some of the same interchanges as Alternates 1 or 2. Pattern 8 has the lowest initial cost. However,better service is afforded the Town of Garrison with interchange Pattern 7 which has the lowest annual costs. This diamond configuration can be located near the existing truck stop. Pattern 7 is shown on page 15 and is the interchange included in the cost summaries.

## Alternate 4

This alternate, like Alternates 1 and 2, has a very limited possible interchange area. This area is confined by the deep cut on the west and the Little Blackfoot River on the east. Interchange locations outside of these confines have excessive costs through extensive excavation or additional structures as well as greater road user costs. Within this area the interchange patterns are affected by the Northern Pacific Railway. The partial cloverleaf layout previously designed by the State Highway Department is labeled Pattern 9. A new layout, Pattern 13, is included in the cost estimates for Alternate 4. Pattern 13 is a simple diamond with one exception. The Helena to Missoula ramp remains north of the railroad track to provide a free-flow entrance to the Interstate. Pattern 13 is geometrically better than Pattern 9 since it is in a flatter area as compared to a sidehill area. Patterns 9 and 13 are shown on page 16.

## No-Stop U.S. 12 Connections

Studies have been made to connect U.S. 12 to the Interstate in a no-stop or free-flow movement for the Helena-Missoula and Missoula-Helena traffic. Few problems arise on the Helena to Missoula leg of any of the interchanges in incorporating the no-stop feature because the movement is simply a right turn and has no cross traffic. The no-stop Missoula to Helena movement is considerably more difficult to attain for there must be adjoining access to the west.

Access to the properties on the south side of the Interstate and east of Warm Springs Creek in the adjoining Gold Creek project will be provided from the existing highway on this project. All interchanges must therefor provide two-way access to the west. A free-flow Missoula to Helena movement retaining this access to the west necessitates additional structures or dictates a partial cloverleaf configuration to eliminate two-way traffic entering a ramp. Alternates 1 and 2 do not lie favorable for a partial cloverleaf. An additional structure would be required on these alternates for complete free-flow off-ramp movement. However, due to the very low volume of traffic expected from the west, a connection in line with the crossroad is proposed. It should be kept in mind that free flow ramps on these alternates in no way reduces the traffic confliction and reduced speed zone of the Town of Garrison itself.

Alternate 3 lies even less favorably for non-stop access off the Interstate to U.S. 12 because the off-ramp must be placed sufficiently west of the Town to allow a usable grade down from the cut in the ridge. Parallel with this ramp must be the access road to the properties at Warm Springs Creek and there is not enough space between the steep hillside and the properties in the town of Garrison for the Interstate and two adjacent roadways. The fill slopes will extend well into the properties. However, the value of these properties does not appear high. Like Alternates 1 and 2, traffic would be routed through the reduced speed area in Garrison.

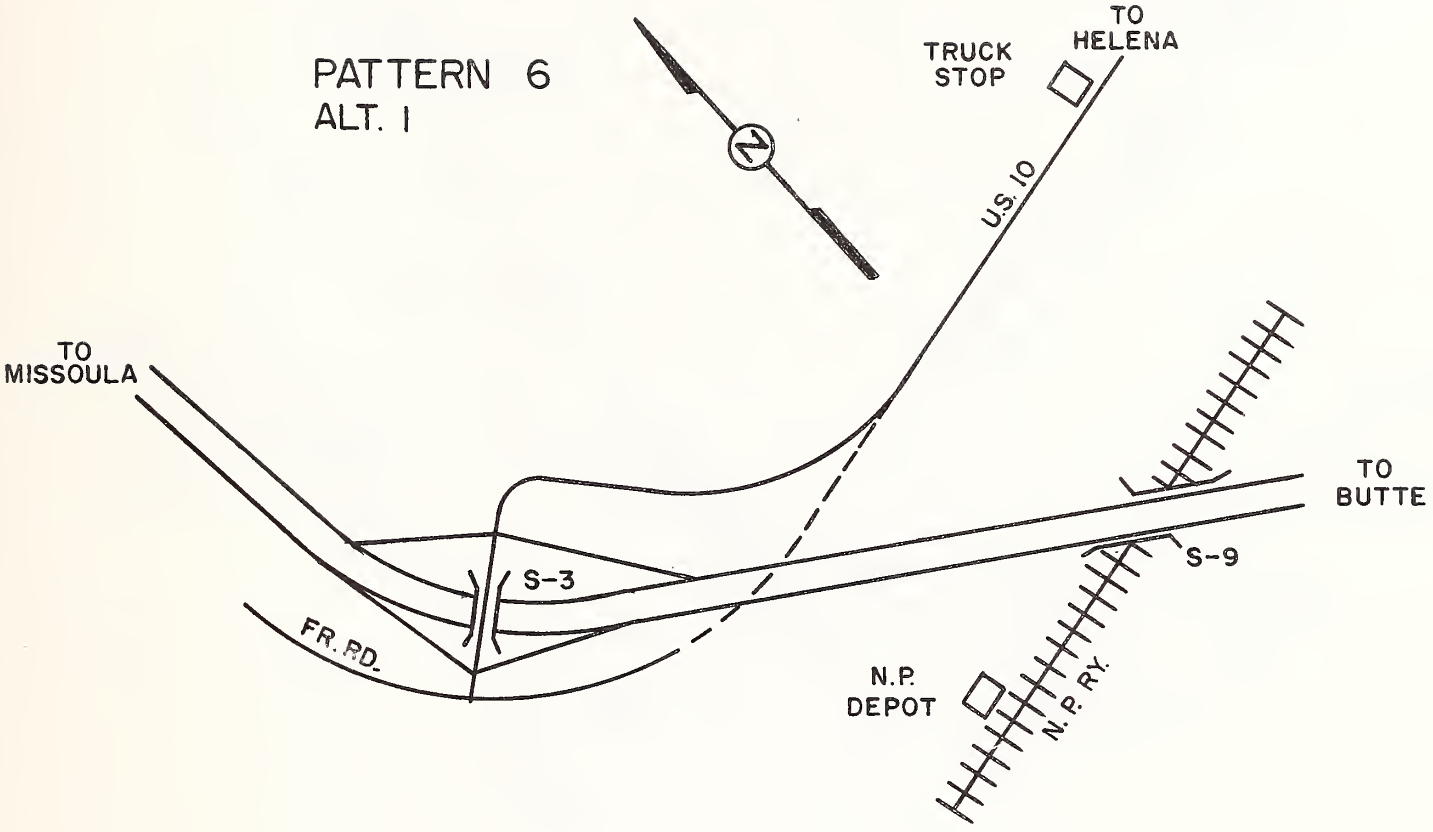
On Alternate 4 a partial cloverleaf configuration is proposed. The ramps would lie in opposing quadrants. An additional structure would be required for the Missoula to Helena ramp over the N.P. Railway. An island between opposing traffic lanes is proposed where this ramp enters the Garrison to Helena roadway to eliminate the wrong way possibility. It would be planned that the Garrison to Helena traffic would stop for the Missoula to Helena traffic. Diagramatic sketches of the no-stop separations are on pages 17 and 18.

## INTERCHANGE CONSTRUCTION COST COMPARISON

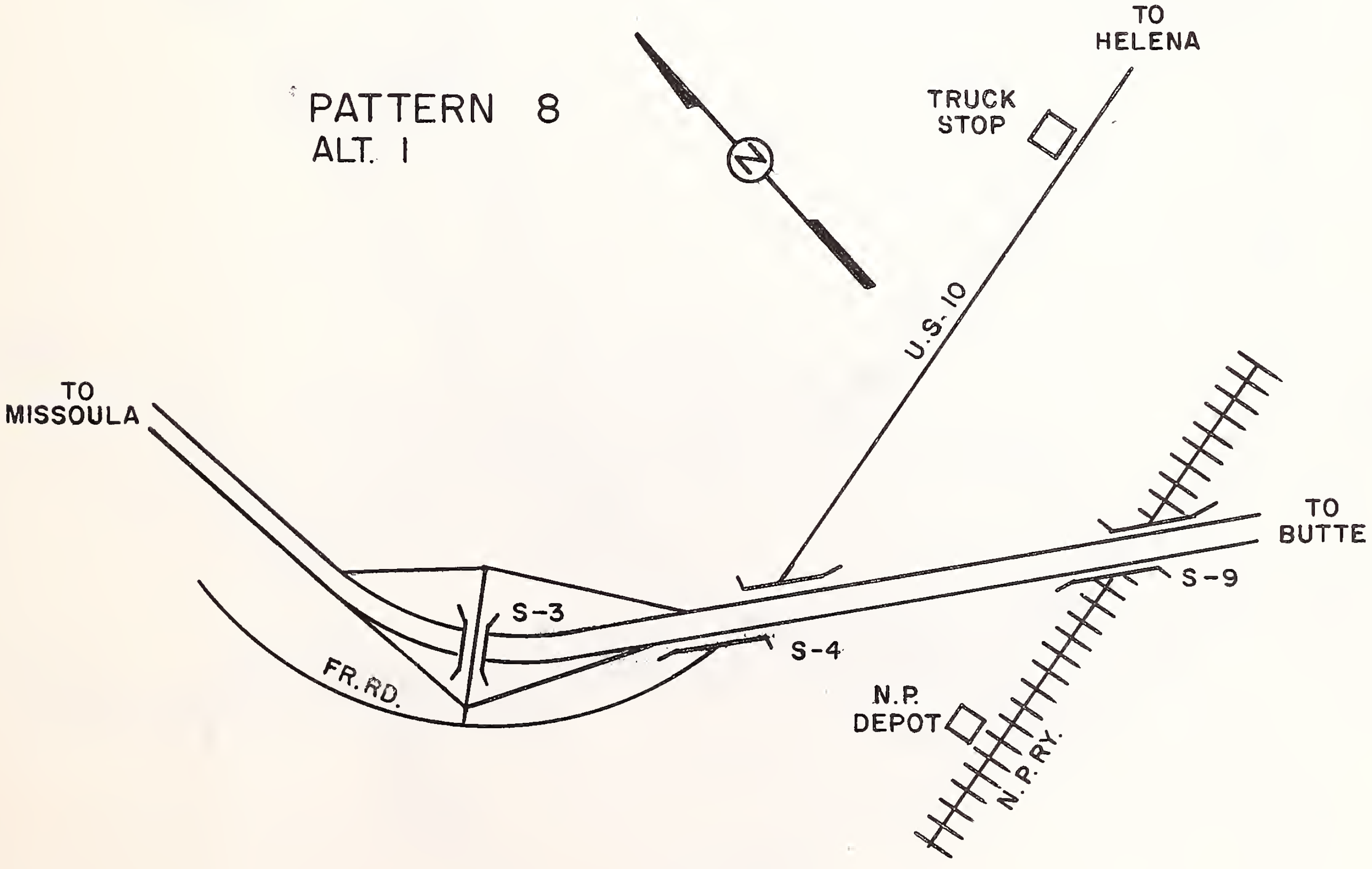
| INTERCHANGE | ITEMS OF COST COMPARISON (In Thousands of Dollars) | | | |
|---|---|---|---|---|
| | EARTHWORK | SURFACING | STRUCTURES | TOTAL |
| *6 - Alternate 1 | $ 407 | $ 66 | $ 166 | $ 639 |
| *7 - Alternate 3 | 285 | 59 | 321 | 665 |
| 8 - Alternate 1 | 224 | 55 | 620 | 899 |
| 8 - Alternate 2 | 263 | 55 | 842 | 1,160 |
| 8 - Alternate 3 | 200 | 55 | 166 | 421 |
| 9 - Alternate 4 | 160 | 68 | 180 | 408 |
| *12 - Alternate 2 | 290 | 66 | 166 | 522 |
| *13 - Alternate 4 | - | 63 | 371 | 434 |
| No Stop for U.S. 12 | | | | |
| Alternate 1 | 413 | 70 | 620 | 1,103 |
| Alternate 2 | 413 | 70 | 842 | 1,325 |
| Alternate 3 | 66 | 59 | 55 | 180 |
| Alternate 4 | 30 | 90 | 251 | 371 |

The interchanges selected for inclusion with the alternates in the total cost summary at the back of this report were those that accrued the least annual cost and are denoted *.

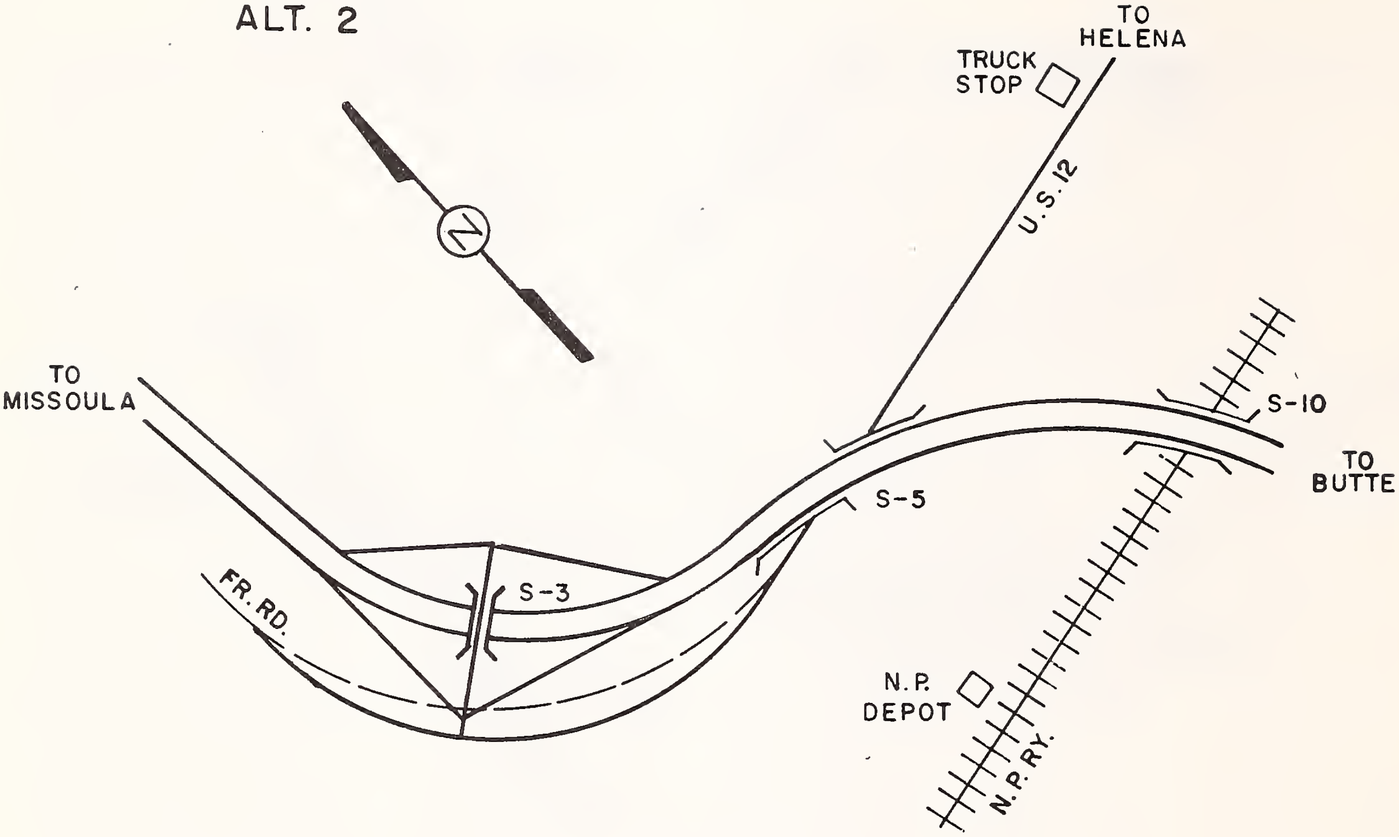
PATTERN 6
ALT. 1



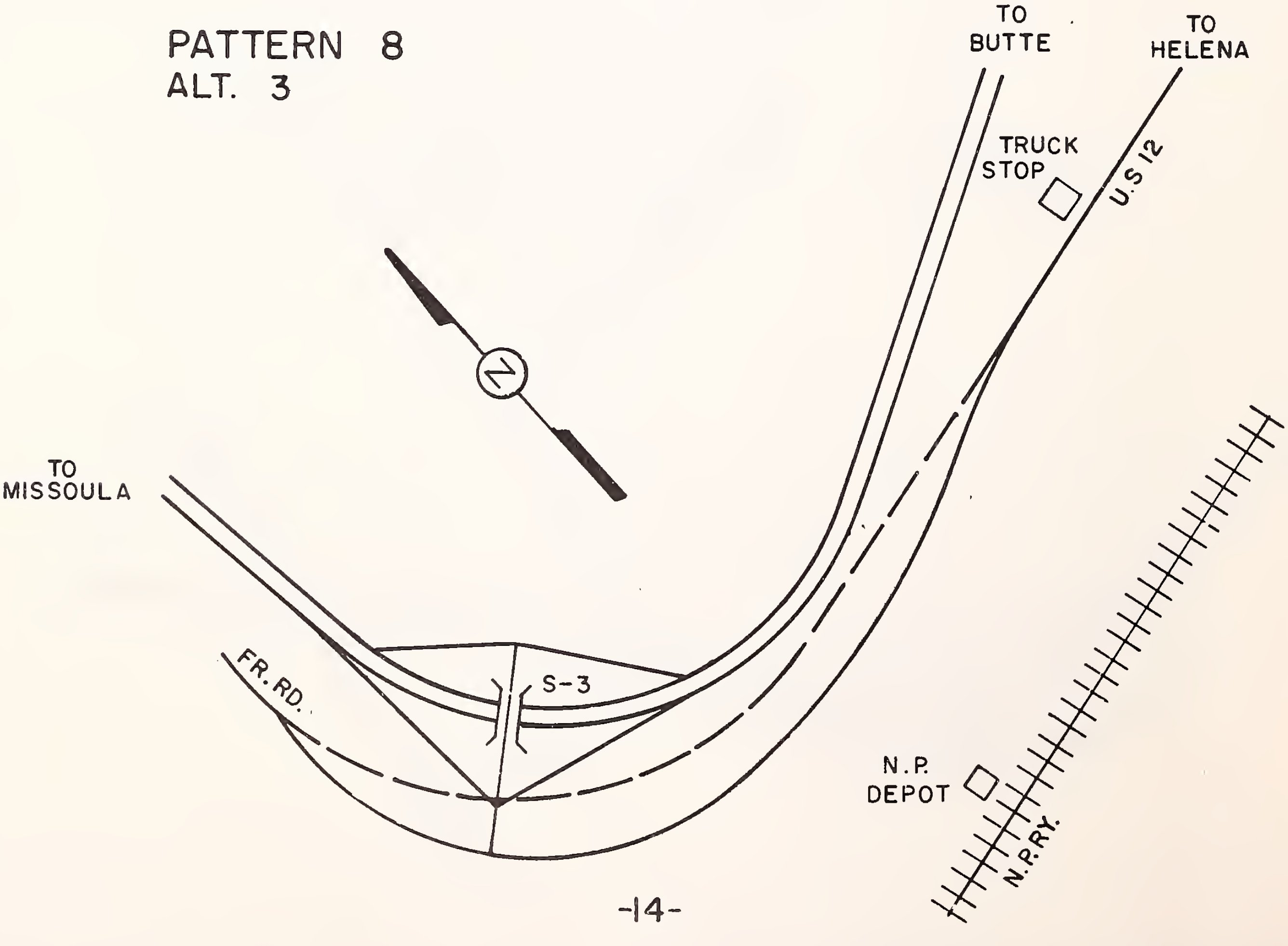
PATTERN 8
ALT. 1



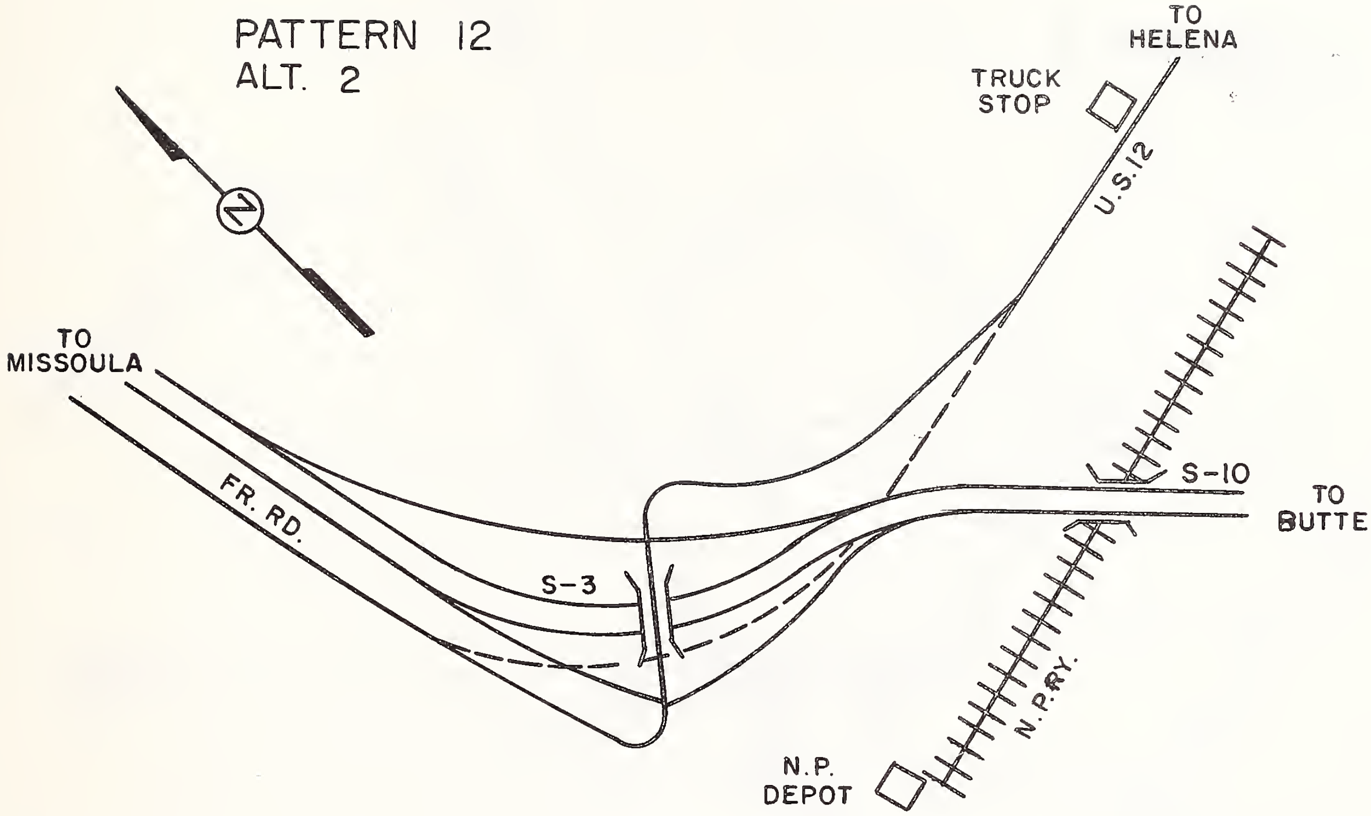
PATTERN 8
ALT. 2



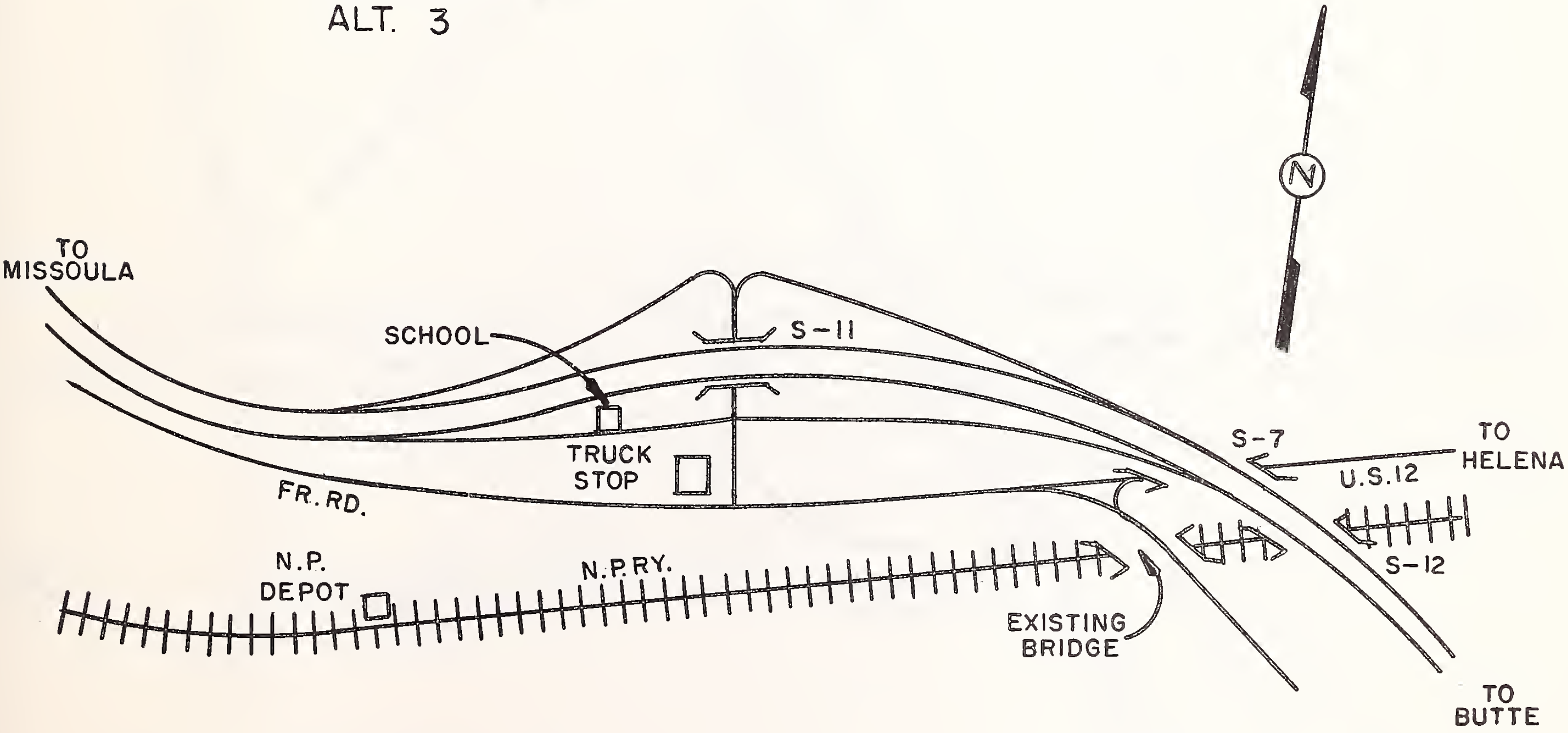
PATTERN 8
ALT. 3



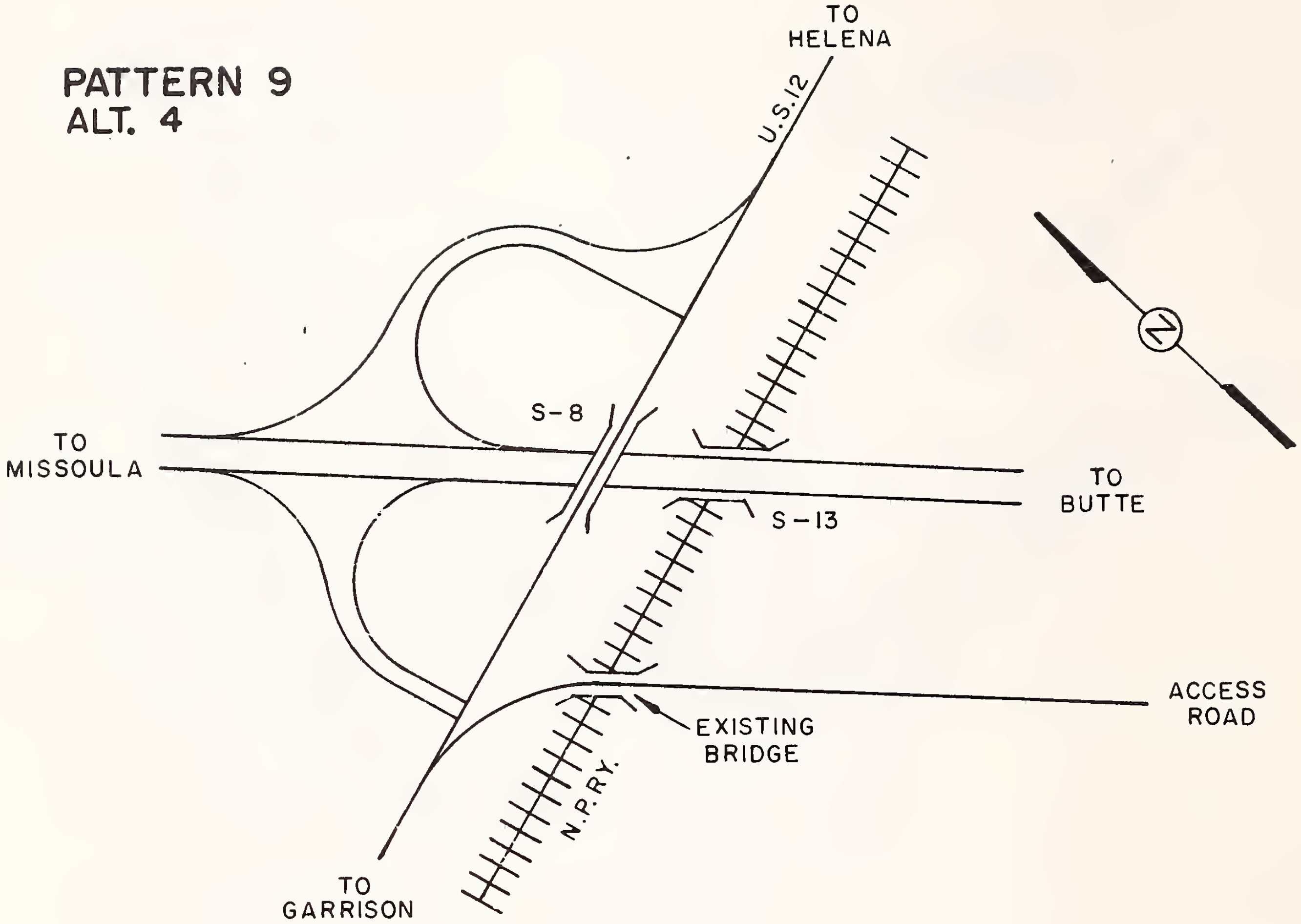
## PATTERN 12
ALT. 2



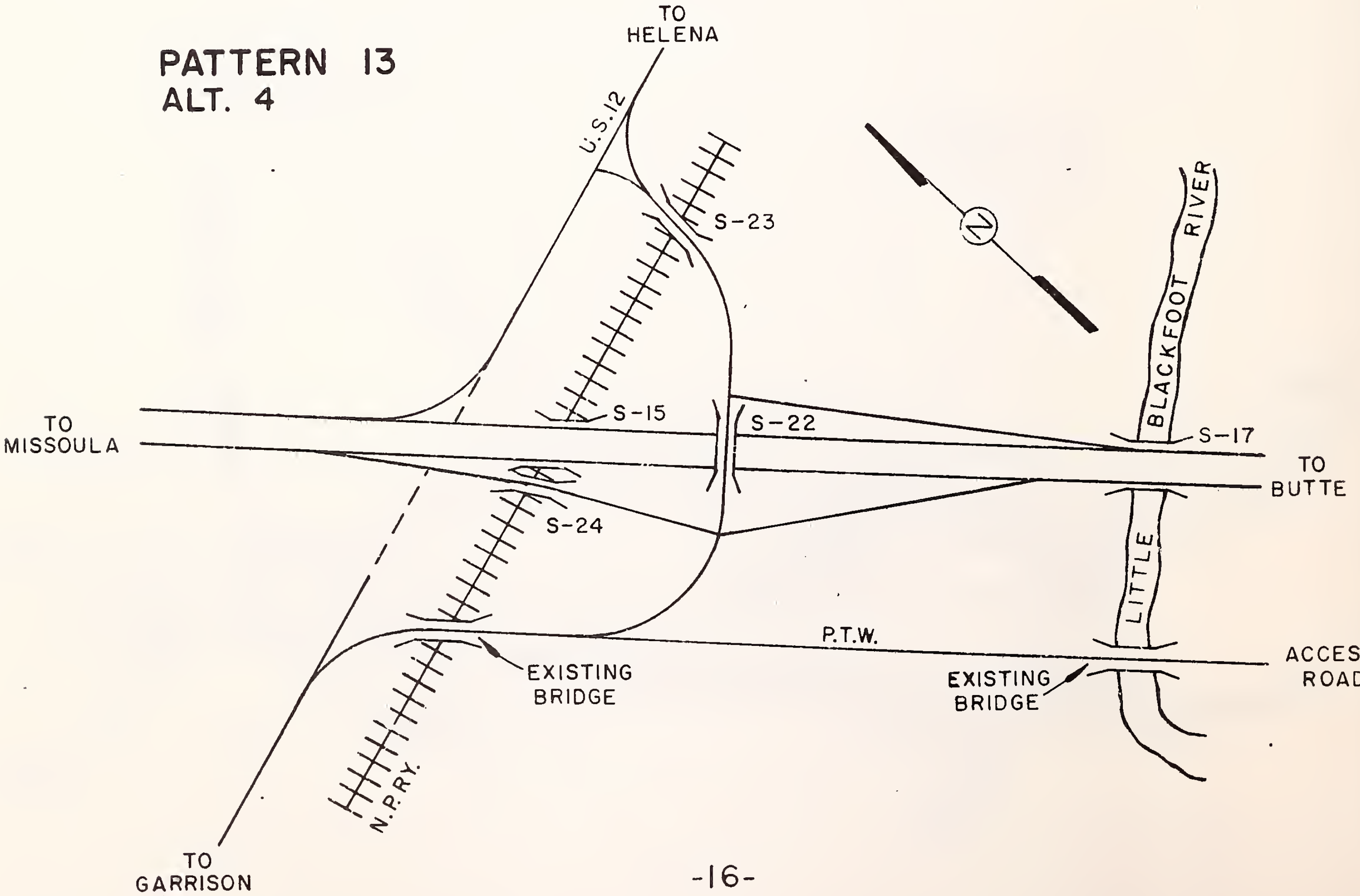
## PATTERN 7
ALT. 3



**PATTERN 9**
**ALT. 4**

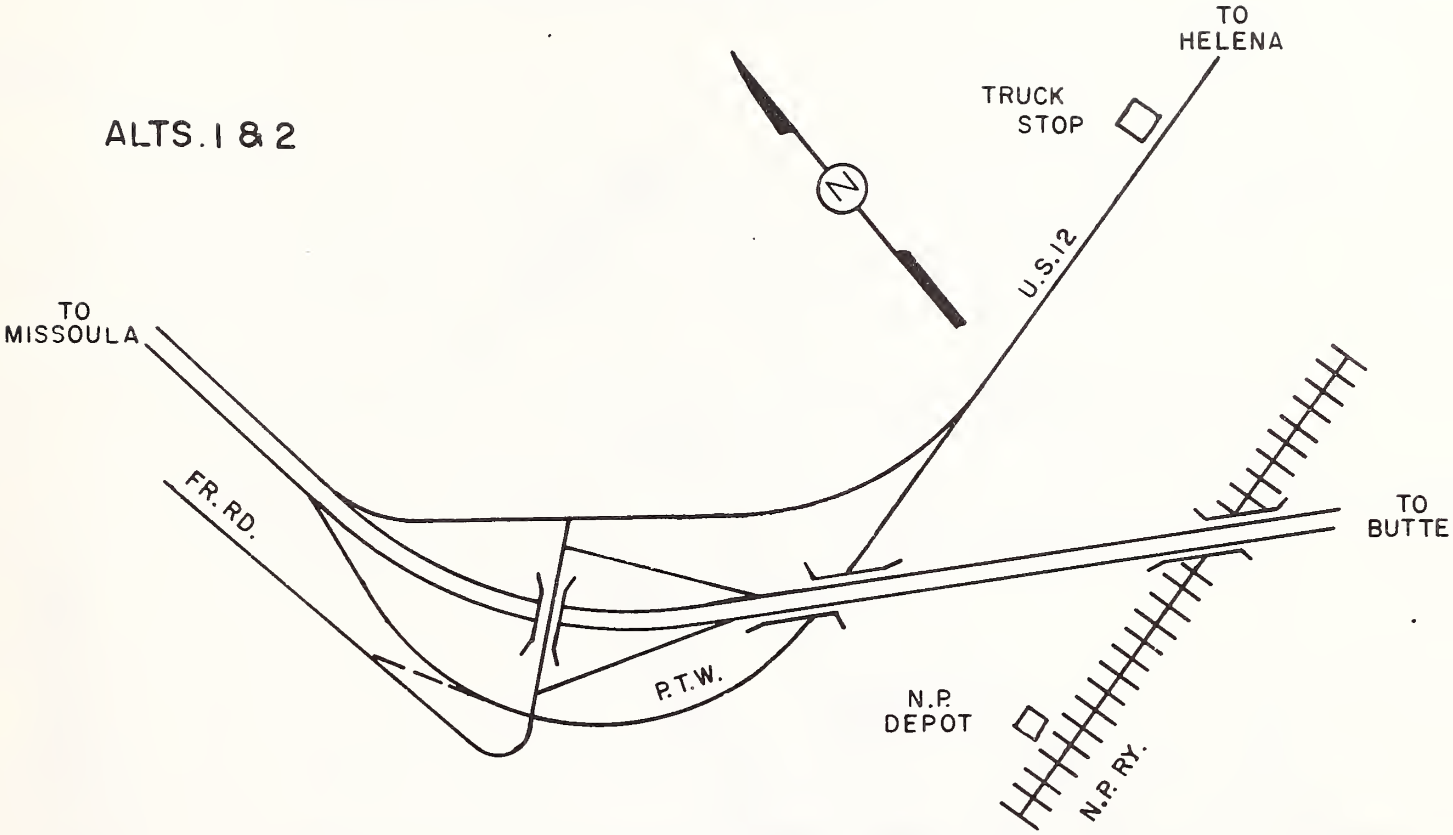


**PATTERN 13**
**ALT. 4**

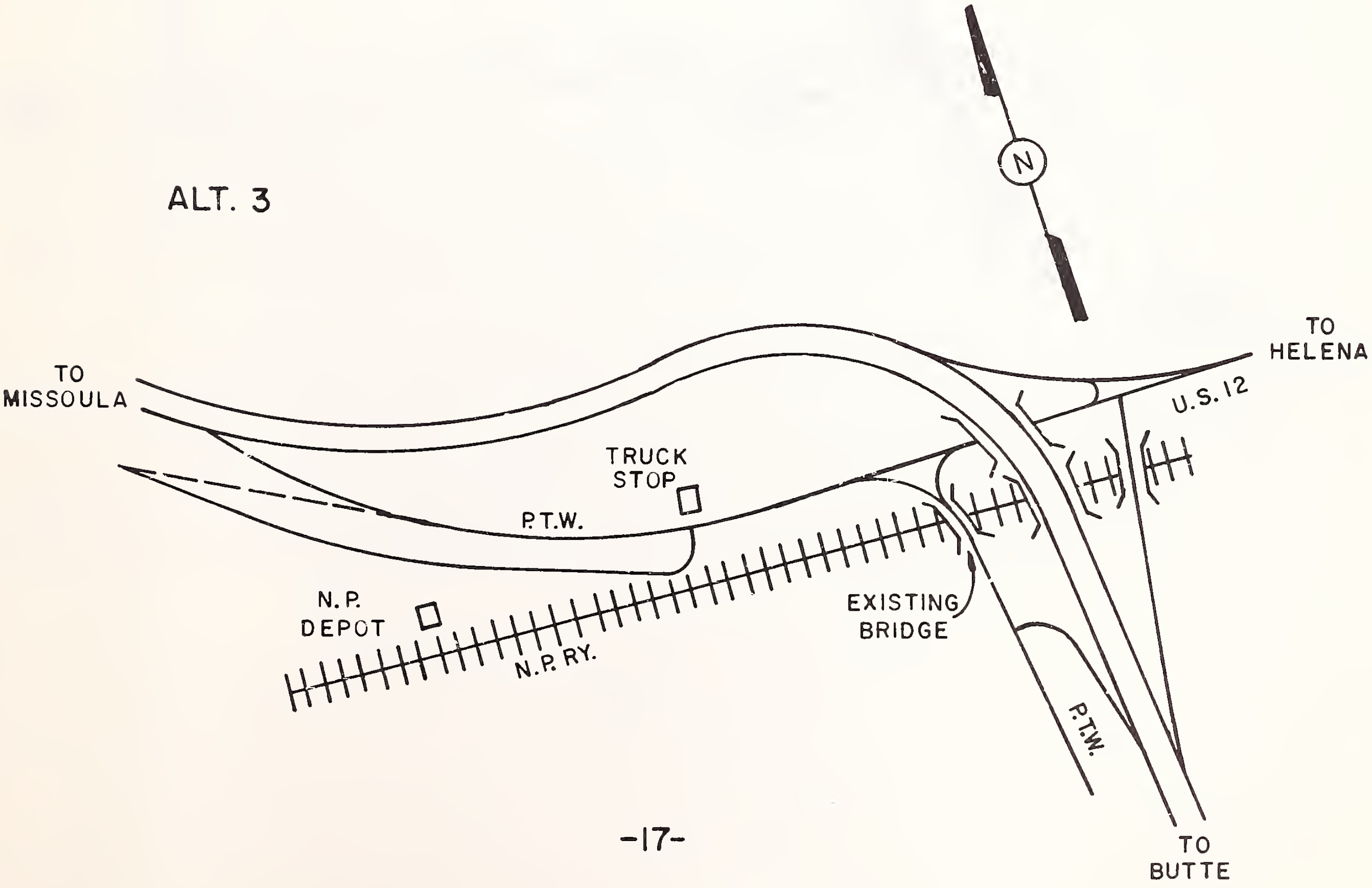


# NO-STOP PATTERNS

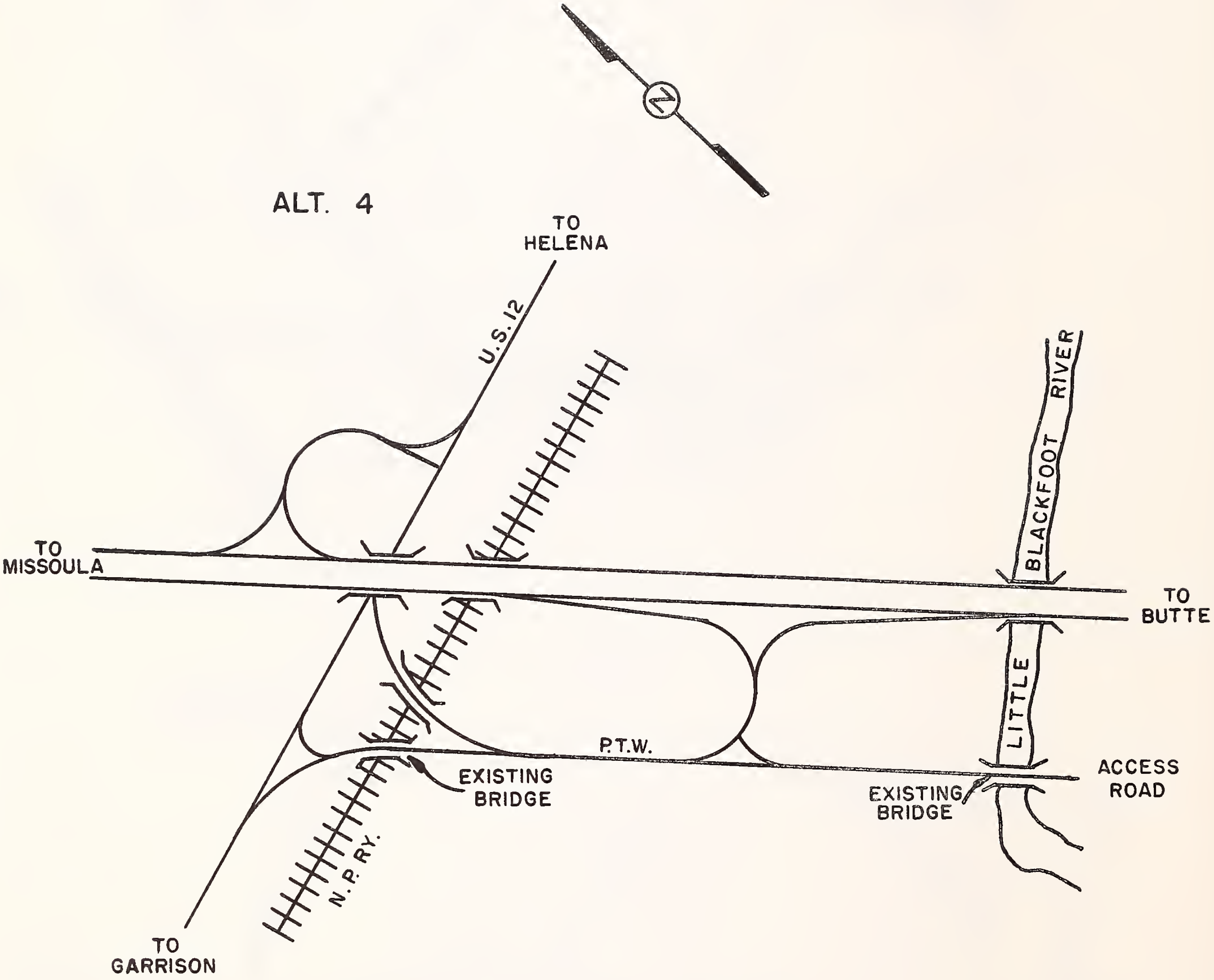
ALTS. 1 & 2



ALT. 3



ALT. 4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BRIDGE
ACCESS
ROAD
EXISTING
BRIDGE
N. P. RY.
TO
GARRISON

# HYDRAULICS AND MAJOR STRUCTURES

## Hydraulics

The study area is traversed by two major drainages, the Little Blackfoot River and the Clark Fork. These two rivers have flows great enough to obviate the use of culverts, particularly since the terrain is flat enough to flood before developing any appreciable depth. Other drainages in the study area are small and can be handled by culverts at a relatively small cost.

Construction of the frontage road adjacent to the Interstate at Station 5+00 will encroach into the river. This will be necessary on all alternates since it has been determined that the most feasible location for the eastbound lanes at the east end of the Gold Creek East project is over the existing highway. The encroachment will not be very large. As planned it does not exceed 20 feet. On Alternates 1, 2 or 3 the encroachment length would be 700 feet. On Alternate 4 the length would be 400 feet.

## Major Structures

Structure cost estimates for this study employing MSH designation Type "A" and Type "IV" prestressed concrete girders and simple and continuous span welded steel girder construction are based on unit square foot costs of $10.50, $11.50, $13.50 and $15.00 respectively. These unit costs were developed after reviewing structure contract awards by the Montana State Highway Commission for the years 1966 and 1967. Areas of structures for estimating purposes have been determined by taking the width as out-to-out of curbs and the length as the center-to-center distance between end bearings. A ten per cent contingency allowance has been added to all structure cost estimates.

Consideration has been given to the use of the existing structure over the railroad and the Little Blackfoot River bridge on the present highway southeast of Garrison. Both structures are relatively new and in excellent condition. Some interchange plans have been able to incorporate the railroad bridge, however, both structures are too narrow for use on the Interstate. An inspection in the field indicates that widening of the structures is possible, but that the additional cost of widening added to the cost of the Interstate construction when aligned with either of these structures exceeds the cost of new structures.

As pointed out in the Geology section of this report embankment material at structure abutments may have a tendency to shear or settle. Various methods can be employed at the time of design to eliminate this problem. Special handling of excavated material, use of special quarried material or slope stabilizing structures are some of the possible solutions. To account for an equivalent construction cost that this item will involve, an additional cost of $0.40 per cubic yard for the material at each abutment has been added into the structure costs.

The identifying structure numbers are shown adjacent to the structures on the location plans. The following summary shows the corresponding structure costs. The cost figure shown for each structure includes a 10% contingency and the additional special abutment material cost.

## STRUCTURE SUMMARY

| Structure Number | Alternate | Service | Length (Feet) | Cost (In Thousands) |
|---|---|---|---|---|
| 1 | 4 | Access Pipe | 300 | $ 40 |
| 3 | 1,2 or 3 | Local Over-Interchange 6, 8 or 12 | 325 | 166 |
| 4 | 1 | Local Under - Interchange 8 | 367 | 454 |
| 5 | 2 | Local Under - Interchange 8 | 475 | 676 |
| 7 | 3 | Local Under | 334 | 490 |
| 8 | 4 | Local Over - Interchange 9 | 315 | 180 |
| 9 | 1 | Interstate Over Railroad | 680 | 1,011 |
| 10 | 2 | Interstate Over Railroad | 515 | 772 |
| 11 | 3 | Local Under - Interchange 7 | 158 | 175 |
| 12 | 3 | Interstate Over Railroad | 230 | 283 |
| 13 | 4 | Interstate Over Railroad | 178 | 208 |
| 14 | 1 or 2 | Little Blackfoot River | 208 | 229 |
| 16 | 3 | Little Blackfoot River | 130 | 173 |
| 17 | 4 | Little Blackfoot River | 215 | 255 |
| 18 | 1 or 2 | Interstate Over Railroad | 285 | 323 |
| 20 | 3 | Access Pipe | 300 | 40 |
| 22 | 4 | Local Over-Interchange 13 | 300 | 169 |
| 23 | 4 | Crossroad Over Railroad | 160 | 100 |
| 24 | 4 | Ramp Over Railroad | 175 | 101 |

## MISCELLANEOUS CONSIDERATIONS

### Right-of-Way

The estimated costs of right-of-way were furnished by the Montana Highway Department. Windshield appraisals by this Consultant confirm this estimate. The estimate covers the costs for severed access.

### Utilities Adjustments.

On all alternates there would be utilities whose locations are coincident with the proposed Interstate Highway. Conflictions will occur primarily on Alternate 3 with the telephone trunk line and the underground 2 inch natural gas service pipe. The length of confliction between Alternate 3 and the telephone line is 3000 feet; with the gas line, 2000 feet.

All of the other alternates will cross the telephone line but will have no confliction with the gas line. Where the alternates cross the railroad there will be some revision of the railroad telegraph. An electric power line must also be crossed on any alternate location.

The costs of the utilities adjustments do not differ greatly between alternates as Alternate 3 with the most utilities adjustments is only $11,000 more in estimated cost than Alternate 4 which has the least utilities confliction.

### Local Service

There is no rural mail service in the Garrison area to date. Mail is held at the post office and picked up by the owners. Two school busses carry students into and through the area. The route originates in Deer Lodge. One bus loads east of Garrison and one west of Garrison, the elementary students are dropped off at the Garrison school and the High School students go on to Deer Lodge.

An additional length of 28 miles will be added to the school bus routes due to an access split in the Gold Creek East project which adjoins this project to the west. A part of the access will be furnished from the westerly end of this Garrison project. A frontage road is proposed in this area to provide this access. Alternate selection influences the length of this frontage road but has no influence on the traffic thatit will carry.

### Maintenance of Traffic

The cost to the highway contractor for maintaining passage and detours through the area under consideration is a very real expense. It will appear in construction bids as a maintenance of traffic item, if used, or else be reflected in higher unit bid prices.

This expense is computed by multiplying the cubic yards excavated in the immediate area adjacent to and below the existing highway by $0.05 per cubic yard. This is the estimated cost of equipment rental and wages accrued. The total cost computed for each alternate is shown in the Cost Summary.

# ECONOMIC ANALYSIS

## General

An economic analysis has been made to compare the alternate location on an annual cost basis. This analysis proportions due consideration to the items that can be evaluated in terms of true cost in dollars.

The road user analysis was made according to the 1960 A.A.S.H.O. Informational Report on "Road User Benefit Analysis for Highway Improvements, Part 1, Passenger Cars in Rural areas." Traffic volume data were provided by the Montana Highway Department. The average annual daily traffic year is assumed as 1980, which covers a 20 year period from 1970 to 1990 and is consistent with the above informational report basis. The 1980 average daily traffic (ADT) was determined on a straight line proportion between furnished 1975 ADT and 1990 ADT.

## Annual Operating Costs

Commercial vehicle traffic was estimated to be 11% of the annual average daily traffic. The unit vehicle operating and time costs for commercial vehicles were considered at 3.5 times that for passenger cars. All unit costs of vehicle expenses were used as published in the previously mentioned A.A.S.H.O. report, except the unit cost of gasoline, which was increased from 32 cents to 40 cents per gallon to reflect the current prices in Montana. For example, the base cost for operation on the Interstate is $0.0934 per vehicle mile. A running speed of 49 MPH was used for the Interstate, 40 MPH for the rural 2-lane U.S. 10 and 12 and 32 MPH in Garrison where a speed zone restriction will be retained. All vehicle operation was considered "free" except where the speed zone exists. This area was considered "restricted."

The primary cost difference between alternates in the road user's cost resulted from the cost computation of the travel length between the locations of the various alternate interchanges and a point common to all interchange traffic movements.

All U.S. 12 (Helena direction) traffic travel distance was computed from a point 4100 feet easterly from the Garrison truck stop. This point lies 1900 feet easterly of the proposed intersection of Alternate 4 and U.S. 12. Garrison traffic was generally computed from the truck stop.

## Annual Costruction and Maintenance Costs

An interest rate of 6% was used as a basis of amortizing the initial construction costs over the estimated service life of the various highway construction items. This is consistent with present practice of the

Montana Highway Commission. The estimated service life of each construction item is shown below:

Right-of-Way & Utilities - 50 Years
Grading and Drainage - 40 Years
Major Structures - 40 Years
Surfacing - 20 Years

Annual maintenance costs are based on type and use of road. Interstate road maintenance is estimated as $3,000 per mile, paved frontage road is $1,000 per mile and gravel access road is $200 per mile.

Total annual costs for the alternate locations are shown in the Cost Summary.

# TRAFFIC VOLUMES & TURNING MOVEMENTS

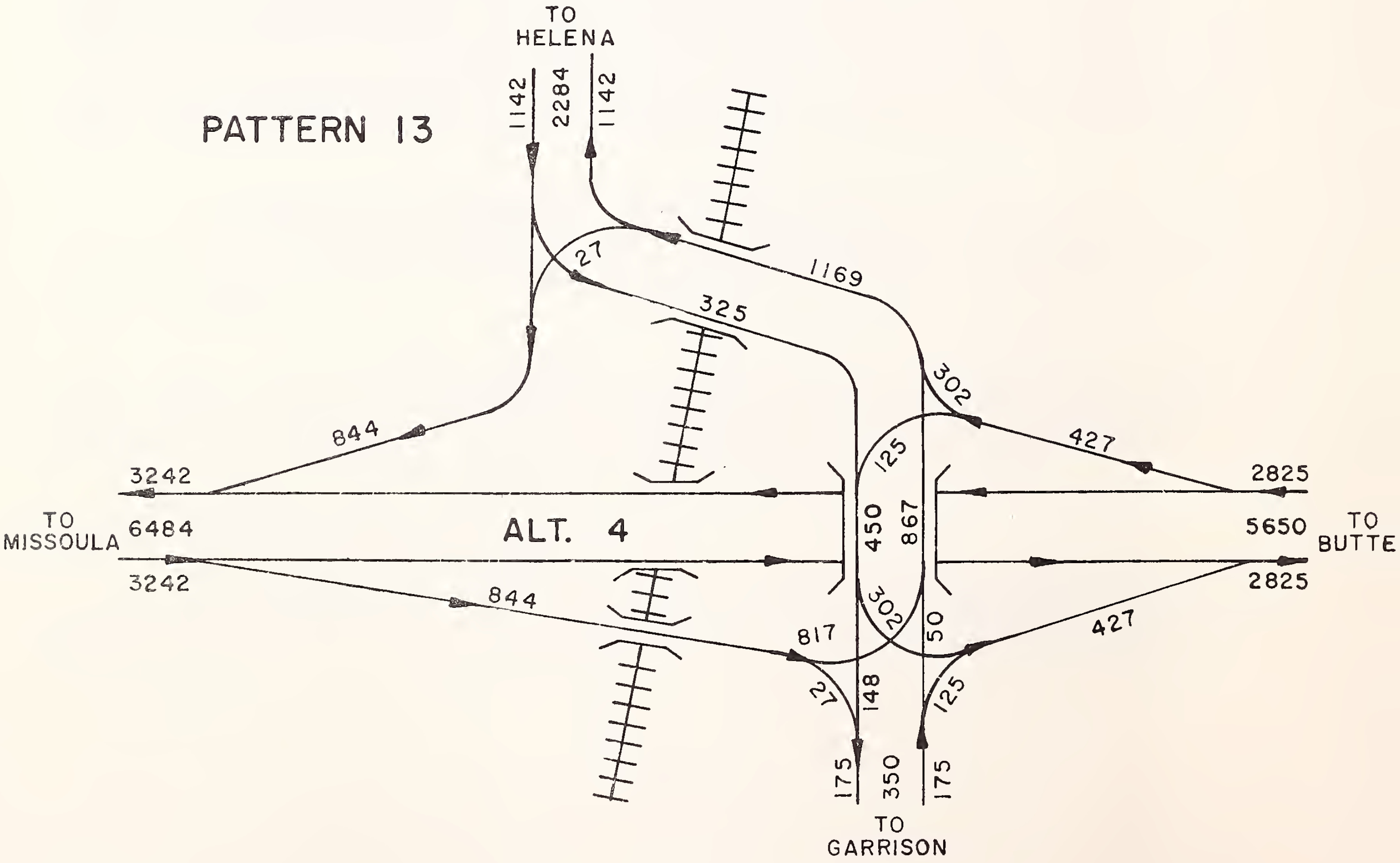
## LEGEND

TURNING MOVEMENTS 1980 ADT 10 →

✳ 10 OR LESS VEHICLES

## NOTES

1. FIGURES FOR AVERAGE DAILY TRAFFIC (ADT) WERE OBTAINED FROM MONTANA HIGHWAY DEPARTMENT



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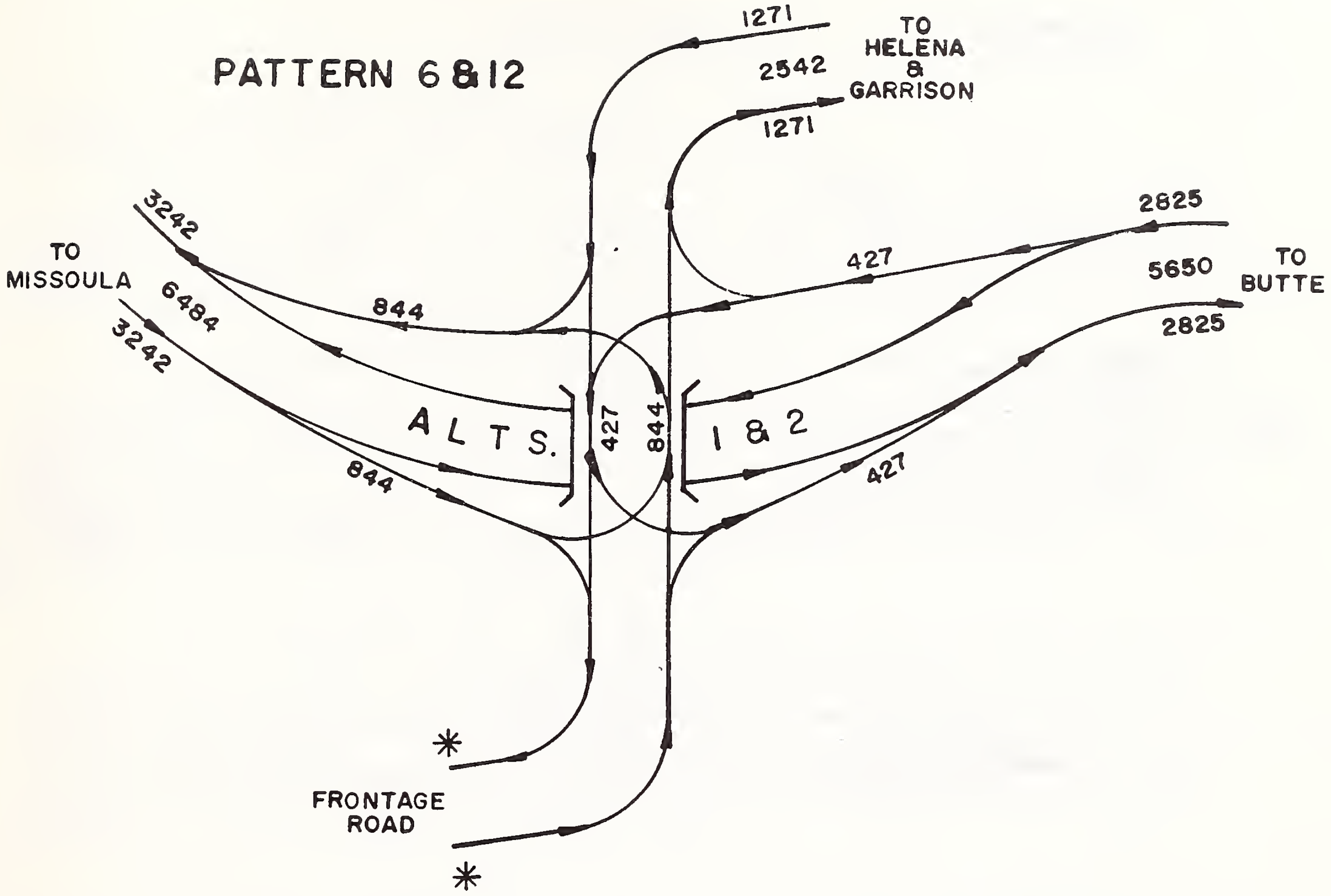
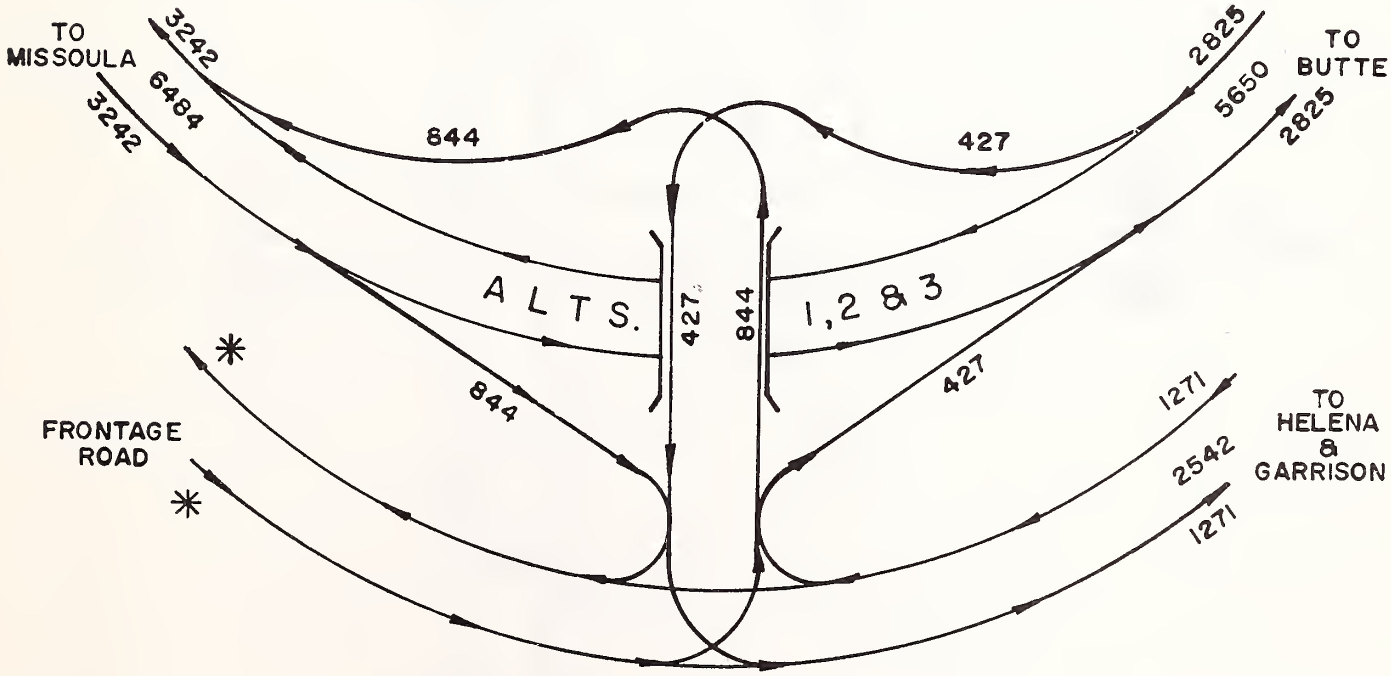
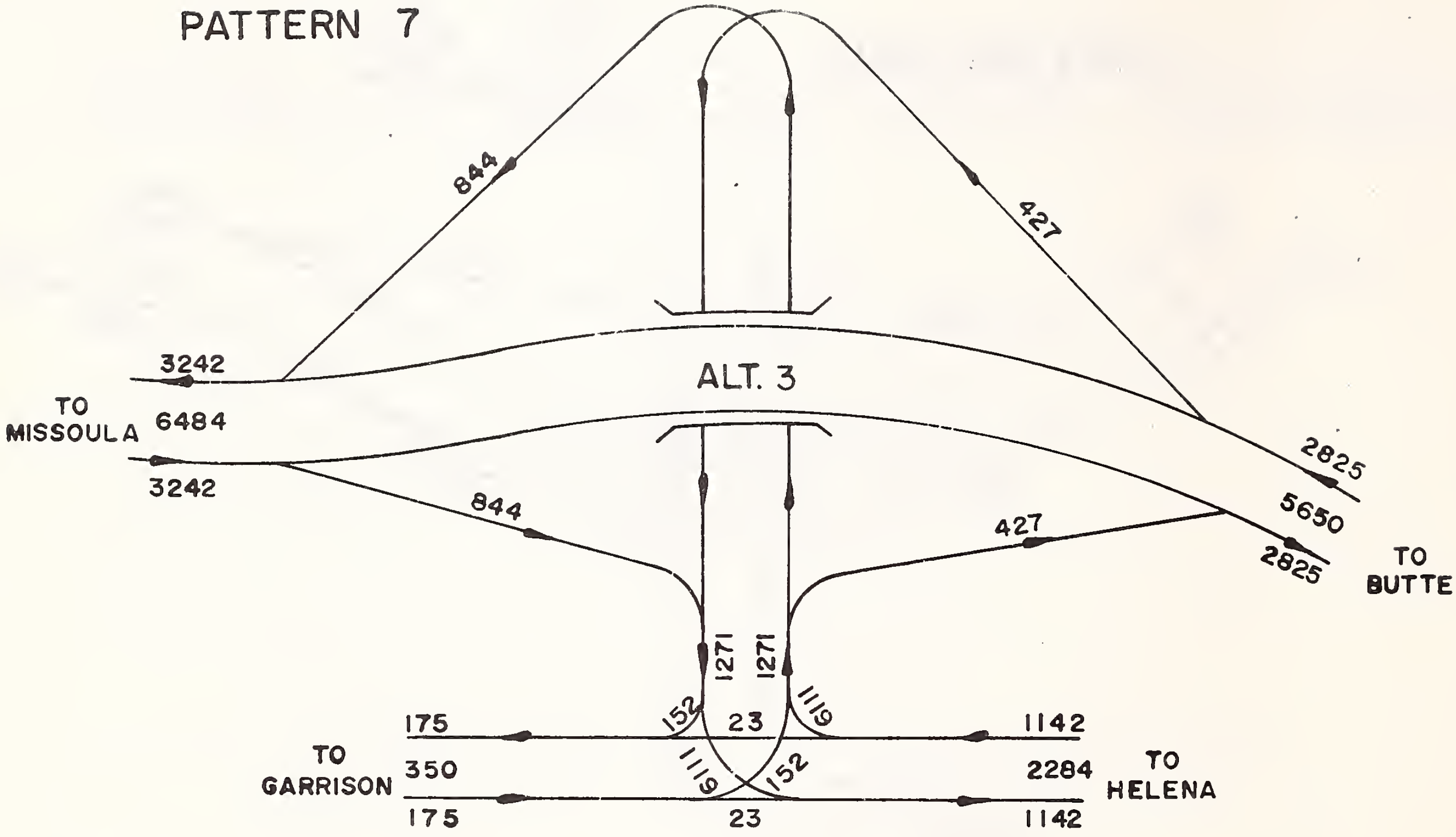


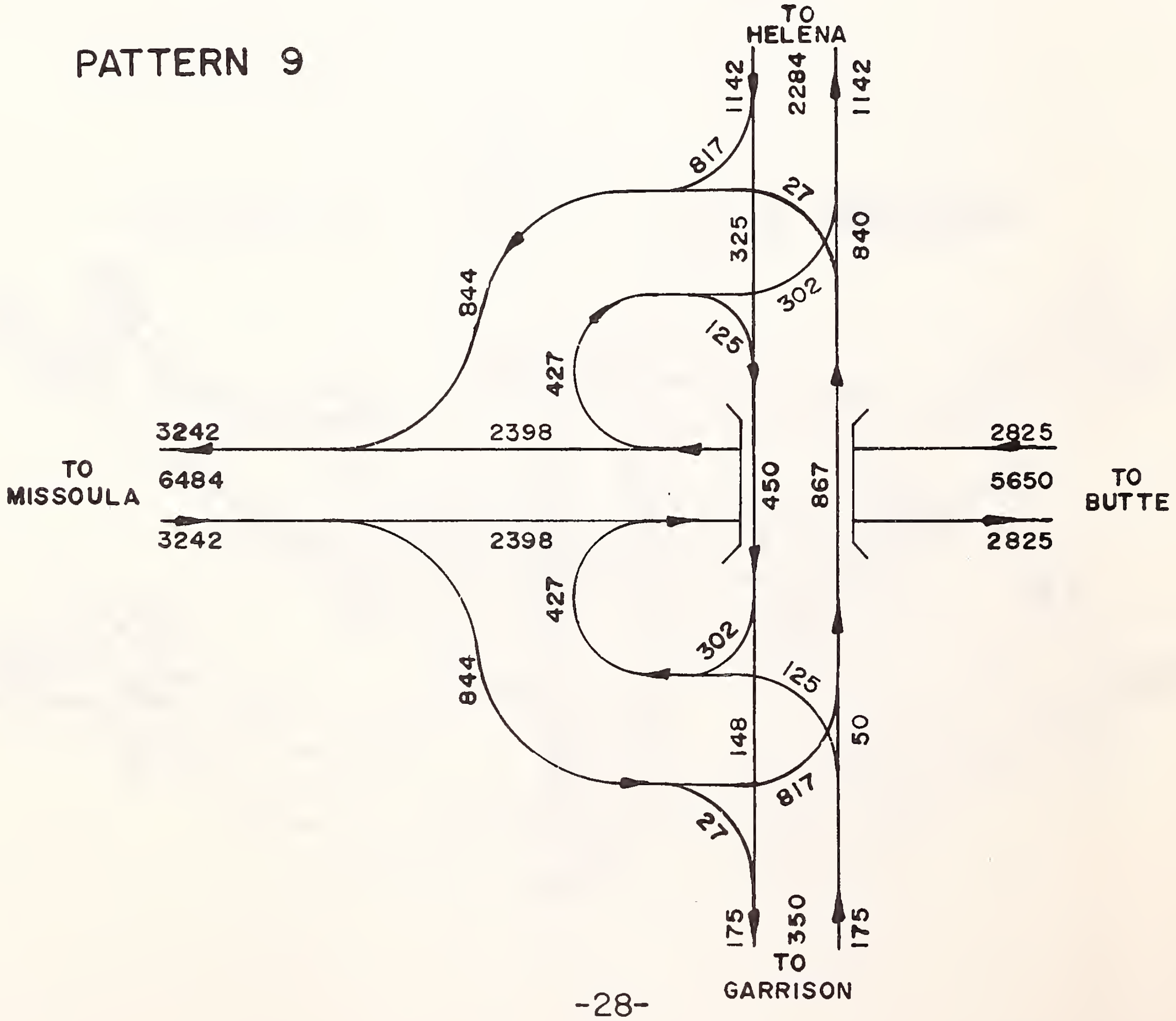
## PATTERN 8



PATTERN 7



PATTERN 9



# COST ESTIMATES

## Basis for Construction Cost Estimates

Where there has been discussion of the items included in the cost summaries, the unit cost has been shown. Other unit costs which are the bases for costs in the summaries and which have not been fully discussed are included in this section.

An estimated unit cost of $0.60 per cubic yard was used for all excavation. This cost is a composite cost for the various materials encountered determined by geological inspection with engineering construction procedures in mind. This price includes haul, placement, compaction, watering and rolling. On all alternates the excavation and embankment were balanced within 10% and a direct 50% cost proportion made of the remainder to obtain a complete balance.

The subexcavation unit cost is comprised of two items, a removal, haul and waste cost and a haul, placement and compaction cost for the replacement material. The replacement material is planned to come from the roadway excavation and the excavation cost is included in roadway earthwork costs. The removal cost is considered to be $0.40 per cubic yard and the replacement cost, $0.45 per cubic yard, giving a total subexcavation unit cost of $0.85 per cubic yard.

The gravel weight for surfacing was computed at 3,200 pounds per cubic yard. Bituminous material use and application rates are in accordance with present Montana State Highway Department practice.

Fencing, clearing and grubbing and small drain costs, though not uniformly constant per unit length were estimated as a unit cost of $327 per station. Shoulder guard rail was figured on all embankment slopes exceeding 15 feet in height at a unit cost of $4.00 per lineal foot.

| GARRISON INTERSTATE LOCATION STUDY | PRELIMINARY COST ESTIMATE |
|---|---|

CONSTRUCTION COST COMPARISON ( In Thousands of Dollars)

| ITEM | ALTERNATE | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Length (Miles | 3.92 | 3.97 | 4.18 | 3.77 |
| Earthwork Volume (Cu. Yd.) | | | | |
| Excavation | 2,109,000 | 1,527,000 | 2,053,000 | 2,847,000 |
| Embankment | 1,950,000 | 1,553,000 | 1,912,000 | 2,843,000 |
| Earthwork | $ 1,148 | $ 878 | $ 1,111 | $ 1,685 |
| Structures | 1,729 | 1,490 | 1,160 | 874 |
| Subexcavation | 132 | 94 | 148 | 43 |
| Surfacing | 563 | 569 | 599 | 541 |
| Guard Rail | 56 | 51 | 22 | 87 |
| * | 68 | 68 | 72 | 65 |
| R/W and Utilities | 83 | 85 | 379 | 114 |
| Maintenance of Traffic | 13 | 13 | 40 | 4 |
| Total Construction Cost | $ 3,792 | $ 3,248 | $ 3,531 | $ 3,413 |
| Cost Relationship + | $ 544 | $ - | $ 283 | $ 165 |

ANNUAL COST COMPARISON (In Thousands of Dollars)

| | | | | |
|---|---|---|---|---|
| Annual Construction Cost | $ 258 | $ 222 | $ 222 | $ 230 |
| Annual R/W & Utility Cost | $ 5 | $ 5 | $ 24 | $ 7 |
| Annual Maintenance Cost | $ 13 | $ 13 | $ 14 | $ 12 |
| Annual Interstate Operating Cost | $ 1,025 | $ 1,031 | $ 1,116 | $ 1,037 |
| Annual Connecting Road Operating Cost | $ 197 | $ 197 | $ 126 | $ 49 |
| Total Annual Cost | $ 1,498 | $ 1,468 | $ 1,502 | $ 1,334 |
| Annual Cost Relationship + | $ 164 | $ 134 | $ 168 | - |

* Some items, though not uniformly constant per unit length, can be estimated as constant; Fencing $100/Sta., Clear & Grub $2000/Mi., Small Drains $10,000/Mi.

+ Difference in Cost over Lowest Alternate

# RECOMMENDATIONS

It is recommended that the alignment designated Alternate 4 in this report with the modified diamond interchange Pattern 13 or the no-stop configuration be accepted as the proper 4-lane location to be designed and constructed for Interstate 90 within the limits defined in this report.

This location is the most acceptable of all alignments investigated because:

1. It provides the best service to U.S. 12 with the most direct connection.
2. It requires the least overall annual cost expenditure.
3. It has significantly lower angular deflection and horizontal curvature, as measured by both the maximum and average degree of curves, than the other locations studied.
4. It does not sever any portion of the Town of Garrison.
5. It is the shortest route and thereby shows the most economical benefit to the road user in providing the lowest operating costs.
6. Alternate 4 will not cause any more construction interference with traffic, and probably less, than any other alternate.

Of major importance are items 1 and 2. Traffic studies show that one fifth of the Interstate traffic will use this interchange. Two thirds of this will be on U.S. 12, the Helena-Missoula and reverse movements and one third on the remainder. It is this relatively large traffic movement that highly influences the recommendation of Alternate 4. Because these road users must travel further mostly through a restricted speed zone to reach the interchange locations beyond Alternate 4, there is a savings of $150,000 annually between Alternate 4 and Alternates 1 or 2, and a savings of $80,000 between Alternate 4 and Alternate 3. This is a sizable figure when compared to the total annual construction cost of $230,000 for Alternate 4.

Employing a Capital Recovery Factor of .07 (average life, all items at 6%) the $150,000 would justify over $2,000,000 in construction costs.

A number of interesting comparisons can be made from the tabulation of construction and annual costs. It shows that Alternate 4 has the second lowest initial construction cost. However, what appears very significant from a road user benefit analysis standpoint is that for an increased one-time initial cost expenditure of $165,000 more than Alternate 2 costs, there will be a total annual cost reduction of $134,000 per year below that for Alternate 2 based on the median traffic volume year of 1980. This continually recurring cost reduction would amount to many times the additional construction cost for Alternate 4. Any additional expenditure in construction costs as required by Alternate 1 and 2 do not show additional savings in annual costs; rather they show an increase in annual costs.

The construction cost of Alternate 4 is about five per cent higher than Alternate 2. It is also about three and one-half per cent less than that for Alternate 3 and ten per cent less than that for Alternate 1.

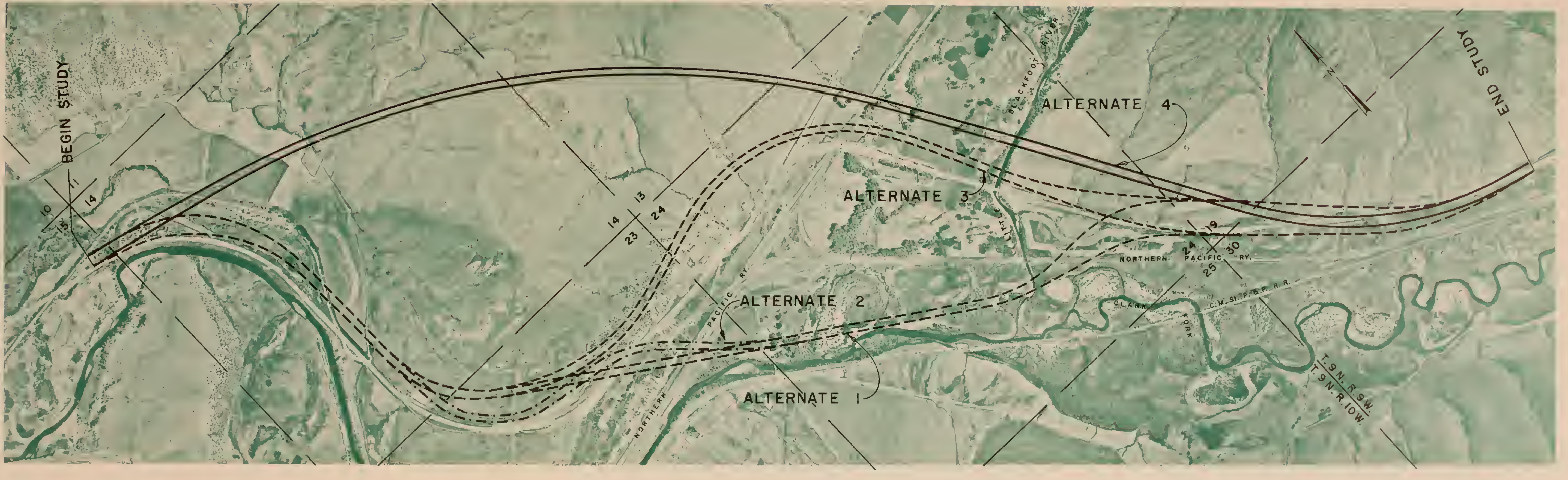
The annual road users operating cost on all alternates is over 80% of the total annual costs used in the economic analysis and thus exerts the greatest cost influence. Annual maintenance costs are essentially the same for all alignments. The annual cost difference for R/W items is not great; however, the initial R/W cost for Alternate 3 is estimated to be much larger than other locations due to the greatest conflict in built-up areas in town.

The individual annual cost totals for Alternates 1, 2 and 3 all exceed that for Alternate 4 by 10% or more.

It is recognized that Alternate 4 is not without certain disadvantages which would not be wholly eliminated but would be reduced to some degree on the other locations. These include the longest deepest cut and the longest extent of high fill. It also requires two lengths of five per cent grade of 4000 feet and 3000 feet.

There are disadvantages on Alternates 1,2 and 3 also which are not present on Alternate 4. These include higher cost, longer length, undesirable connections, and increased horizontal curvature. Sharp curvature and steep grades should both be minimized in the design of a high standard highway. However, where a selection of the two must be made it seems prudent to favor grades. This is based on the past uninterrupted trend to increase vehicle power which decreases the importance of grades. The problem of traversing curves, on the other hand, cannot be overcome by present or foreseeable vehicle characteristics but only through a change in the physical configuration of a road alignment.

## LOCATION PLAN



# PLAN PROFILE LEGEND

## PLAN DATA

SCALE: 1" 1000'

| | |
|---|---|
| INTERSTATE ALIGNMENT | ═══ |
| SECTION LINES | — — — |
| FRONTAGE ROADS<br>CROSS ROADS & RAMPS | ——— |
| STRUCTURE | ━⊐⊏━ |
| CHANNEL CHANGE | ▨ |

D = DEGREE OF CURVATURE, SIMPLE CURVE
Dc = DEGREE OF CURVATURE, SPIRAL CURVE

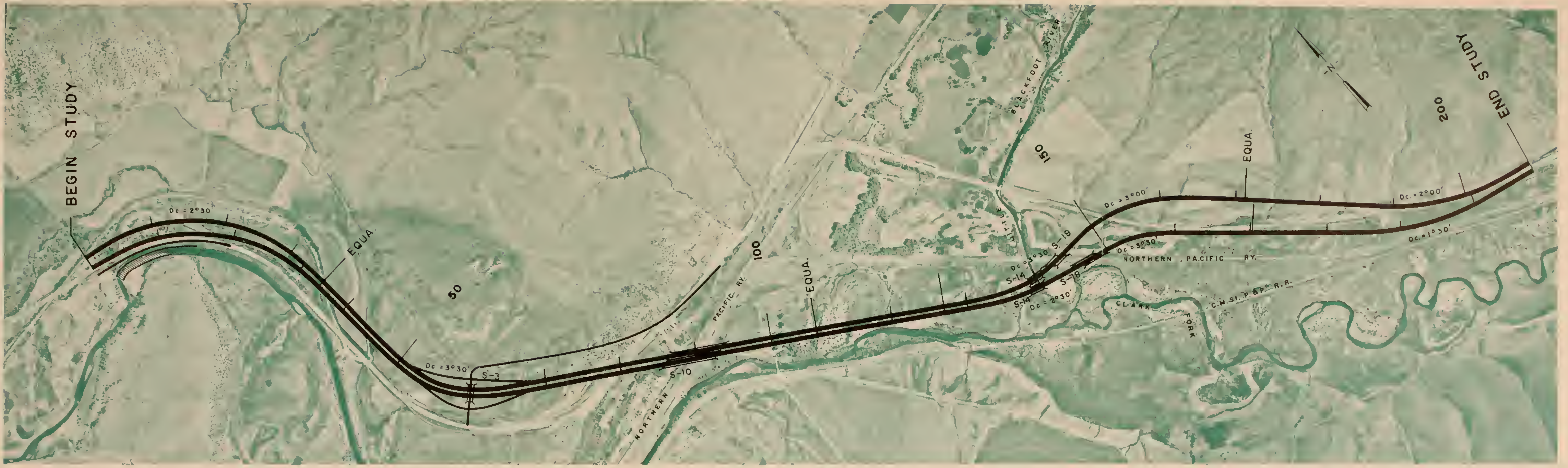
## PROFILE DATA

SCALE: HORIZONTAL 1" = 1000', VERTICAL 1" = 100'

| WESTBOUND | | EASTBOUND | |
|---|---|---|---|
| GRADE LINE | ——— | GRADE LINE | - - - - |
| GROUND LINE | ▨ | GROUND LINE | ∼ |

NOTE: WHEN ONLY ONE GROUND & GRADE LINE IS SHOWN, EASTBOUND & WESTBOUND PROFILE ARE IDENTICAL

V.C. = VERTICAL CURVE POINT OF CURVATURE TO POINT OF TANGENCY ON VERTICAL CURVE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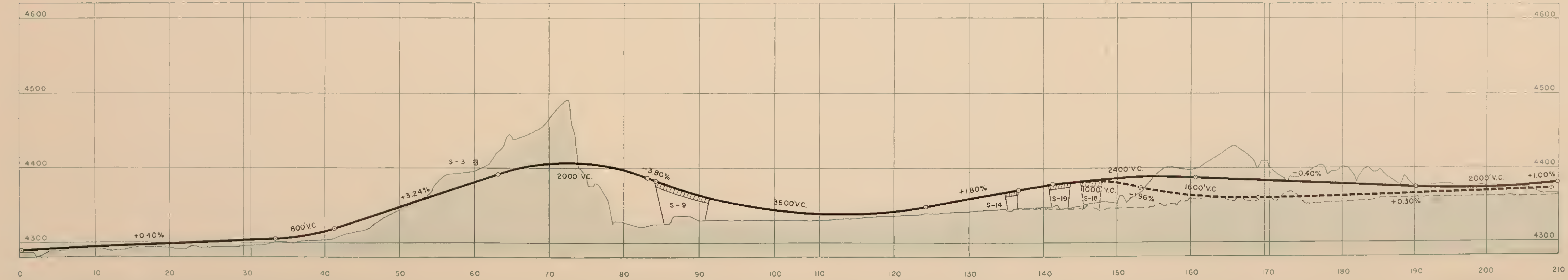
Dc = 2°30'
EQUA.
50
Dc = 3°30'
S-3
S-10
NORTHERN PACIFIC RY.
100
EQUA.
LITTLE
BLACKFOOT RIVER
150
S-14
S-14
Dc = 3°30'
S-19
S-18
Dc = 2°30'
Dc = 3°30'
NORTHERN PACIFIC RY.
CLARK FORK
C.M.St.P.&P. R.R.
Dc = 3°00'
EQUA.
Dc = 2°00'
Dc = 1°30'
200
END STUDY
N

## ALTERNATE I


4600
4500
4400
4300
+0.40%
800' V.C.
+3.24%
S-3
2000' V.C.
-3.80%
S-9
3600' V.C.
+1.80%
S-14
S-19
S-18
1000' V.C.
2400' V.C.
-1.96%
1600' V.C.
-0.40%
2000' V.C.
+1.00%
+0.30%
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
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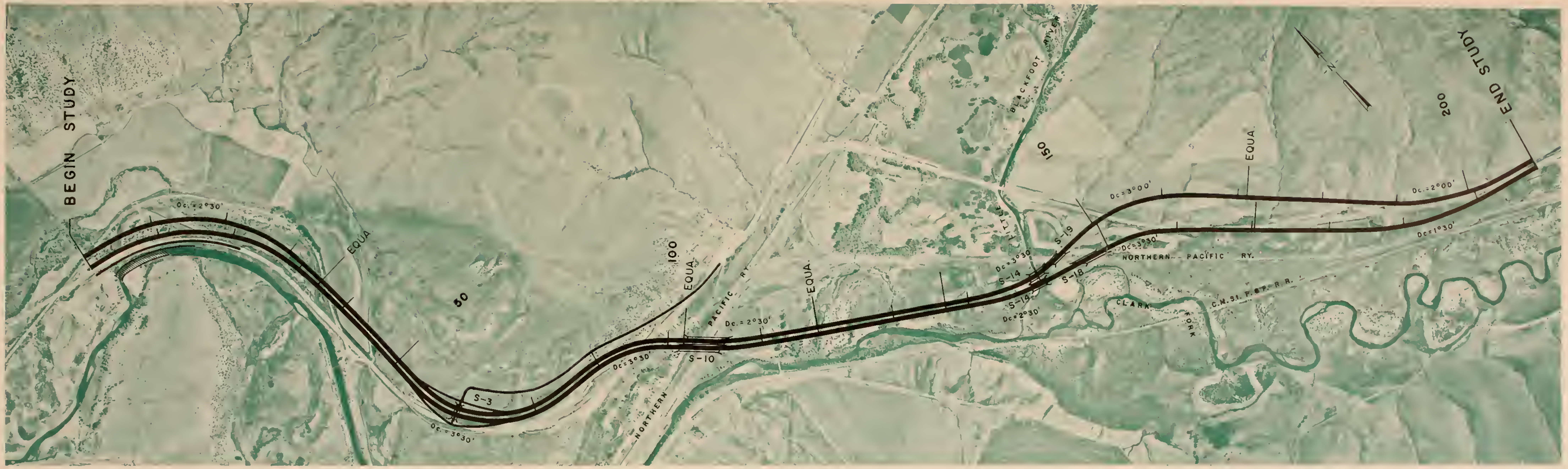
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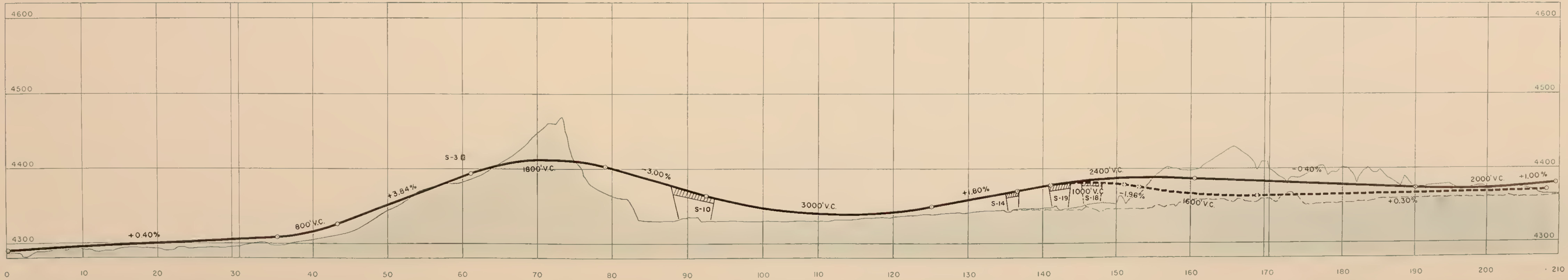
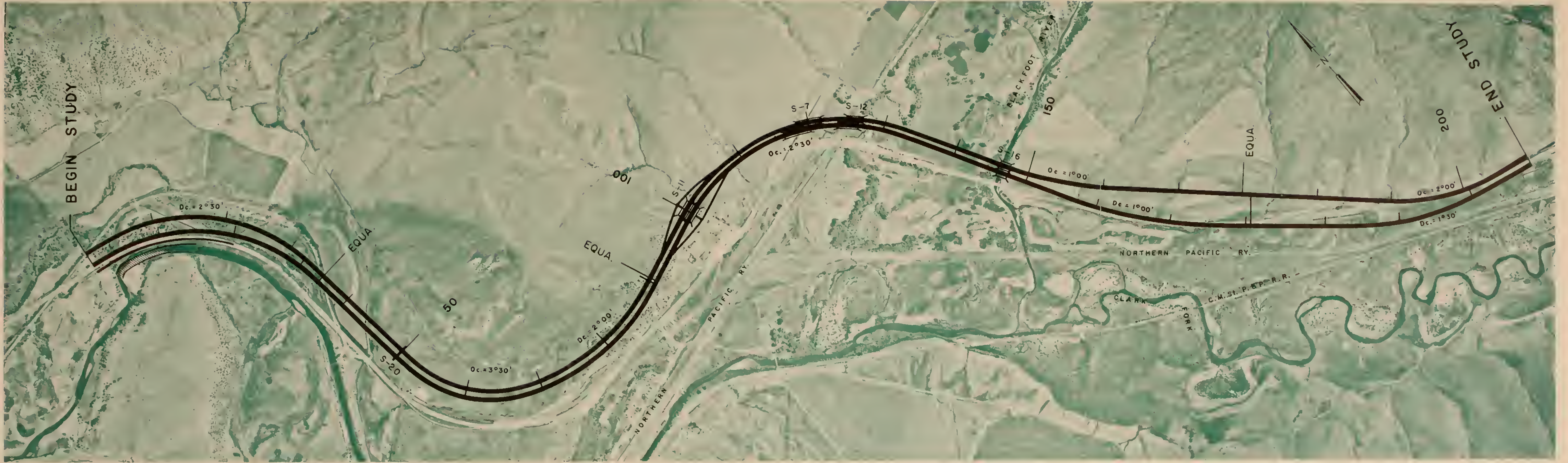
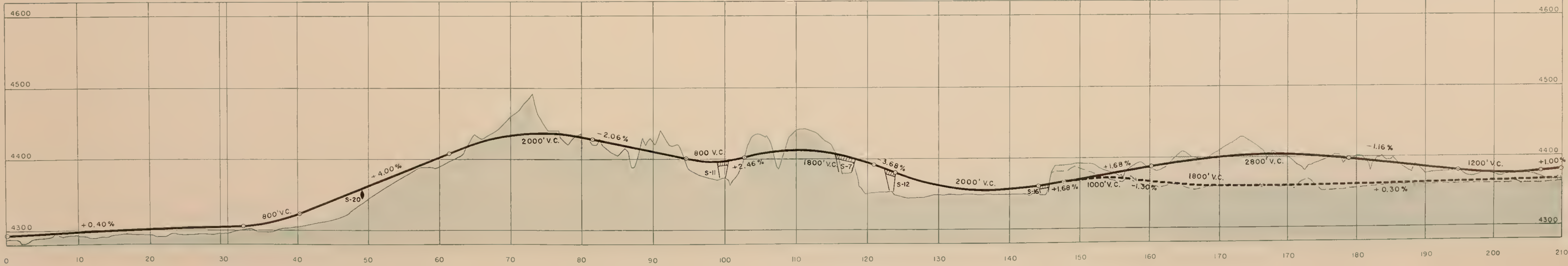
EQUA
50
S-3
Dc.=3°30'
Dc.=3°30'
NORTHERN
PACIFIC
RY.
100
EQUA
S-10
Dc.=2°30'
EQUA
LITTLE
BLACKFOOT RIVER
150
Dc=3°30'
S-14
S-14
Dc=2°30'
S-19
S-18
Dc=3°30'
NORTHERN PACIFIC RY.
CLARK FORK
C.M.St.P.&P.R.R.
Dc=3°00'
EQUA
Dc.=2°00'
Dc=1°30'
200
END STUDY
N

## ALTERNATE 2


4600
4500
4400
4300
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
+0.40%
800' V.C.
+3.84%
S-3
1800' V.C.
-3.00%
S-10
3000' V.C.
+1.80%
S-14
S-19
1000' V.C.
S-18
2400' V.C.
-1.96%
1600' V.C.
-0.40%
+0.30%
2000' V.C.
+1.00%


BEGIN STUDY
Dc = 2°30'
EQUA.
50
S-20
Dc = 3°30'
Dc = 2°00'
EQUA.
100
S-11
Dc = 2°30'
S-7
S-12
S-16
BLACKFOOT RIVER
150
Dc = 1°00'
Dc = 1°00'
EQUA.
200
Dc = 2°00'
Dc = 1°30'
N
END STUDY
NORTHERN PACIFIC RY.
NORTHERN PACIFIC RY.
CLARK FORK
C.M.St.P.&P. R.R.

## ALTERNATE 3


4600
4500
4400
4300
+0.40%
800'V.C.
S-20
+4.00%
2000'V.C.
-2.06%
800 V.C.
S-11
+2.46%
1800'V.C.
S-7
-3.68%
S-12
2000'V.C.
S-16
+1.68%
1000'V.C.
+1.68%
-1.30%
1800'V.C.
2800'V.C.
-1.16%
+0.30%
1200'V.C.
+1.00%
0
10
20
30
40
50
60
70
80
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100
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120
130
140
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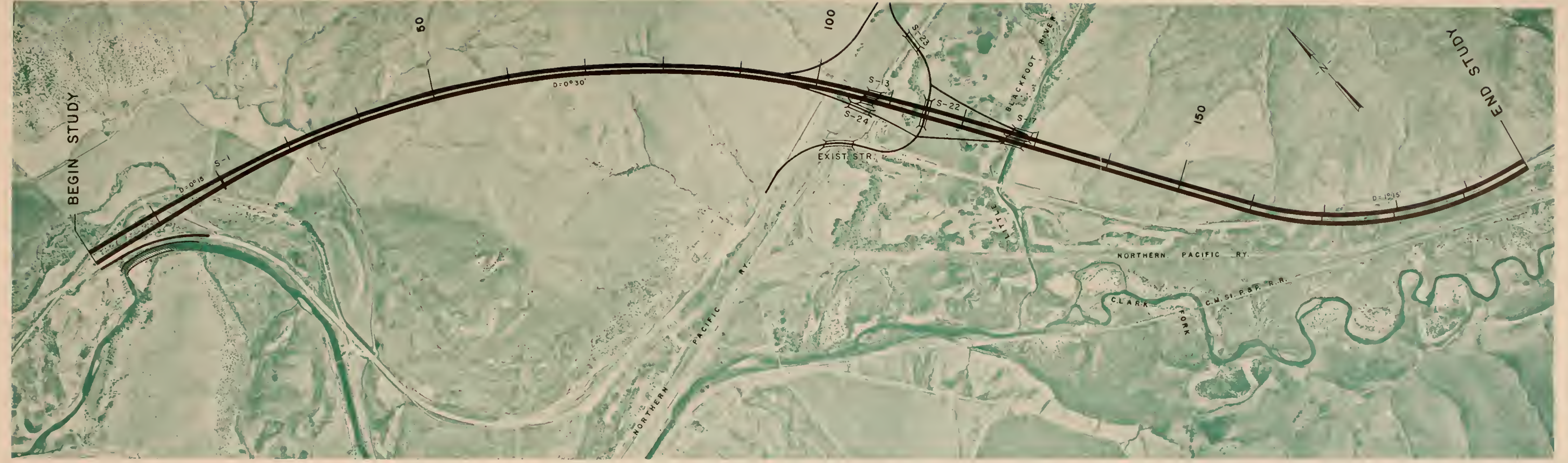
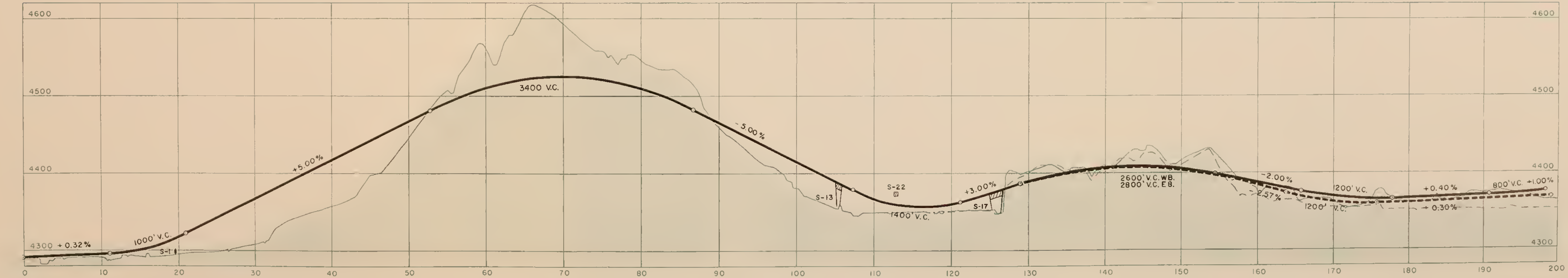
160
170
180
190
200
210


BEGIN STUDY
S-1
D=0°15'
50
D=0°30'
100
S-23
S-13
S-24
S-22
EXIST. STR.
BLACKFOOT RIVER
S-17
LITTLE
150
N
END STUDY
D=1°15'
NORTHERN PACIFIC RY.
NORTHERN PACIFIC RY.
CLARK FORK
C.M.St.P.&P. R.R.

## ALTERNATE 4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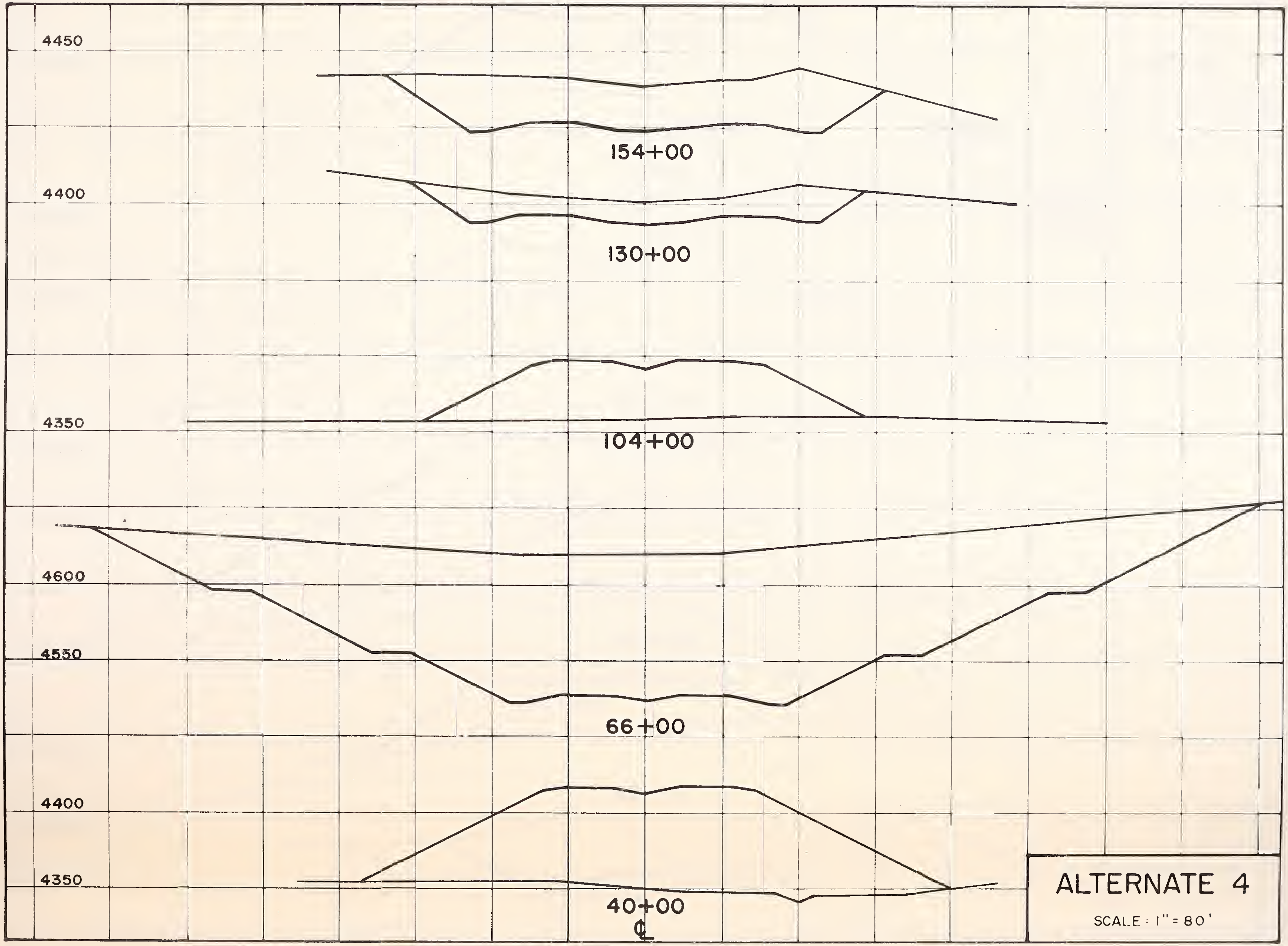
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
+0.32%
1000' V.C.
S-1
+5.00%
3400 V.C.
-5.00%
S-13
S-22
1400' V.C.
+3.00%
S-17
2600' V.C. WB.
2800' V.C. EB.
-2.00%
-2.57%
1200' V.C.
1200' V.C.
+0.40%
+0.30%
800' V.C.
+1.00%



ALTERNATE 4

SCALE : 1" = 80'